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# A Study of the Halftone Dot Characteristics of Rapid Access Halftones

John Gilliatt

# A STUDY OF THE HALFTONE DOT CHARACTERISTICS OF RAPID ACCESS HALFTONES

by

John P. Gilliatt

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the School of Printing in the College of Graphic Arts and Photography of the Rochester Institute of Technology

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Thesis Advisor: Professor Joseph Noga

School of Printing
Rochester Institute of Technology
Rochester, New York

CERTIFICATE OF APPROVAL

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MASTER'S THESIS

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This is to certify that the Master's Thesis of

John P. Gilliatt

with a major in Printing Technology
has been approved by the Thesis Committee as satisfactory for the thesis requirement for the Master of Science degree at the convocation of

September, 1983
date

Thesis Committee: Joseph Noga
Thesis Advisor

Joseph Noga
Graduate Program Coordinator

William A. Paker
Director or Designate

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Characteristics of Rapid Access Halftones

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## ABSTRACT


Rapid access processing is a photographic processing method that combines high temperature processing and high energy developing agents to obtain very short induction periods, and thus, reduced processing times.

In order to obtain maximum quality from the process, the rapid access halftone percent dot areas must be correctly evaluated according to established aim points. Traditional evaluation methods, either visual or instrumental, produce errors. These errors are the partial result of the unique dot characteristics of the process. These characteristics include soft, fringed dots; dots with low Dmax, found particularily in the shadow areas; loss of dot area on the tips of the halftone dots during plate exposure; and high fog in the highlight areas.

The illustration of the differences in dot fringe characteristics of a rapid access and a conventional lith halftone imaged with main exposures only were determined visually by the use of microphotographs illuminated with oblique illumination, and quanitatively by microdensitometer traces and film contacting the original halftone films. In all cases, the rapid access halftone dots had a more highly fringed area when compared to the conventional lith halftone.

The test designed to compare percent dot area of first generation rapid access halftones by zero referencing the dot area meter on the identified ghost dot to the percent dot area of their second generation hard dot contact films produced a poor correlation between the two sets of films. Of the three first generation halftones imaged with a main, main plus flash and main plus bump exposure, the main plus bump exposure produced the poorest correlation, particularly in the midtone area of the halftone scale.

The compensation method designed to determine the effective percent dot area of first generation rapid access halftones by applying percent dot area correction factors found under various halfone exposure conditions effectively reduced percent dot area error.

# CHAPTER I

## Introduction and Problem Statement

Rapid access processing is not a new concept to the photographic community. The technique has been practiced for several years in the processing of x-ray films. In the graphic arts industry, rapid access processing has been utilized in tray systems for the preparation of line and contact films since the late 1960's. Generally, rapid access processing is a technique employed simply to reduce the amount of time required to produce an acceptable image. "The most common types of work best suited to rapid access processing are camera line work, negatives, positives: contact work, lines or halftones; RC type papers: phototypesetting films and RC type papers: screened prints from camera negative through enlarger: duplicating positives or negatives on RC paper: copy-dot applications such as newspaperwork; and medical x-rays with their own appropriate developers."[1] More recently, rapid access processing has been extensively used to process halftone films generated by laser scanning of color separations.

Absent from the above applications are first generation halftone films (films produced directly from continuous-tone images) made by traditional contact screening methods. Until recently, the quality of first generation halftone films processed by rapid access methods was considered unacceptable. The process produced poor halftone dot structure due to poor halftone dot edge quality (sharpness), low maximum obtainable density (Dmax), high minimum density (fog), short copy density range produced by the halftone screen (screen range), and, consequently, poor tone rendering. Many of these problems have been overcome by the recent development of contact screens designed specifically for use with rapid access films and processing.

Prevalent in the literature is a wide variety of terminology and ambiguity in its treatment of rapid access processing. Rapid access processing used to generate first generation halftone films, as used in the context of this research, have the following characteristics:

1. A contact screen designed and manufactured specifically for use with rapid access films and processing

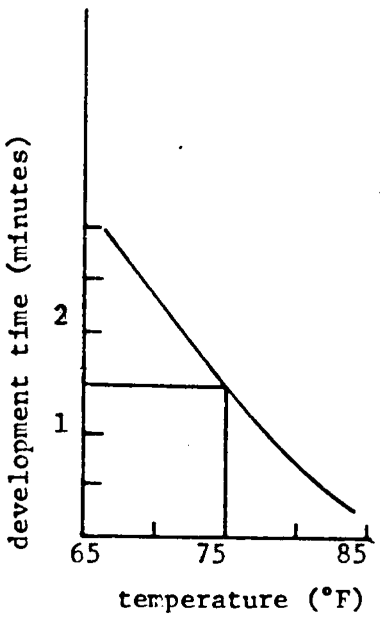
2. A moderately high contrast, continuous-tone film, with a low film fogging tendency

3. A continuous-tone, non-infectious developer, containing auxiliary developing agents such as phenidone and metol, maintained at temperatures of approximately 100°F

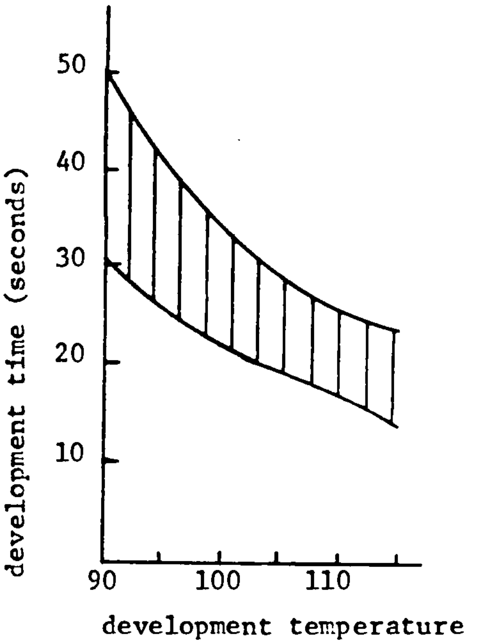
4. Machine processing in batch or replenishment processor designs yielding dry films in approximately two minutes

Under the listed processing conditions, rapid access processing, compared to conventional lith processing, produces lower film contrast in the toe region of the film's characteristic curve, halftone dots with a lower Dmax and greater dot fringe, and shorter induction periods (time required to obtain a visible image) resulting in accelerated development times.

The primary advantage of rapid access processing is increased productivity due to decreased processing time. Lith processing requires four and one-half to six minutes, while rapid access processing is accomplished in one and one-half to two minutes dry to dry.




lith processing




rapid access processing

Fig.1. Optimum time and temperature for lith processing (left) and (right) illustrating wide latitude between development time for rapid access processing (taken from Printing Today, September 1979)

Another advantage is that rapid access processing offers greater processing latitude. As illustrated in Figure 1, there is a wider range of acceptable developing times for each developer temperature as compared to lith processing. Associated with greater processing latitude is the less critical nature of replenishment with rapid access processing. Rapid access developers can not be overreplenished and only after serious underreplenishment do the effects become noticeable.[2] With this processing latitude and stability, makeovers are reduced. With the addition of phenidone and metol as auxiliary developing agents, the developing action is less sensitive to the bromide level. As a result, changes in developer activity, as it flows from high or low density film images, that produce directional development effects such as developer and bromide streaks and adjacency effects are eliminated. Last, chemical inventories are reduced because the single solution, pre-mixed rapid access developer concentrate serves as both working solution and replenisher.

By comparison, lith processing requires careful monitoring of activity to maintain the optimum development time and temperature for a given film and chemistry combination. To maintain dot quality, replenishment is critical and must be accurately delivered to the working solution. Lith developers are composed of two solutions (A and B), and their total replenishment chemistry (including fixer) can equal as many as four separate solutions.

Two disadvantages are associated with rapid access processing. First, exposure latitude is less than with lith film, thus requiring more precisely timed exposures. Second, due to the shortened development time, rapid access films have a lower Dmax (4.5 to 5.0) than lith films (5.5 and higher).[3] This may present problems when attempting to produce halftone shadow dots having sufficient density necessary to maintain their dot size during succeeding stages of the reproduction, i.e., platemaking.

In comparing rapid access halftones to lith negatives, the overall tone gradation of rapid access halftones is quite good, but the rapid access halftones lack sharpness.[4] To achieve quality comparable to lith halftones, halftone soft dots and the amount of dot fringe produced by rapid access processing must be minimized. Figure 2 illustrates the concept of dot fringe.

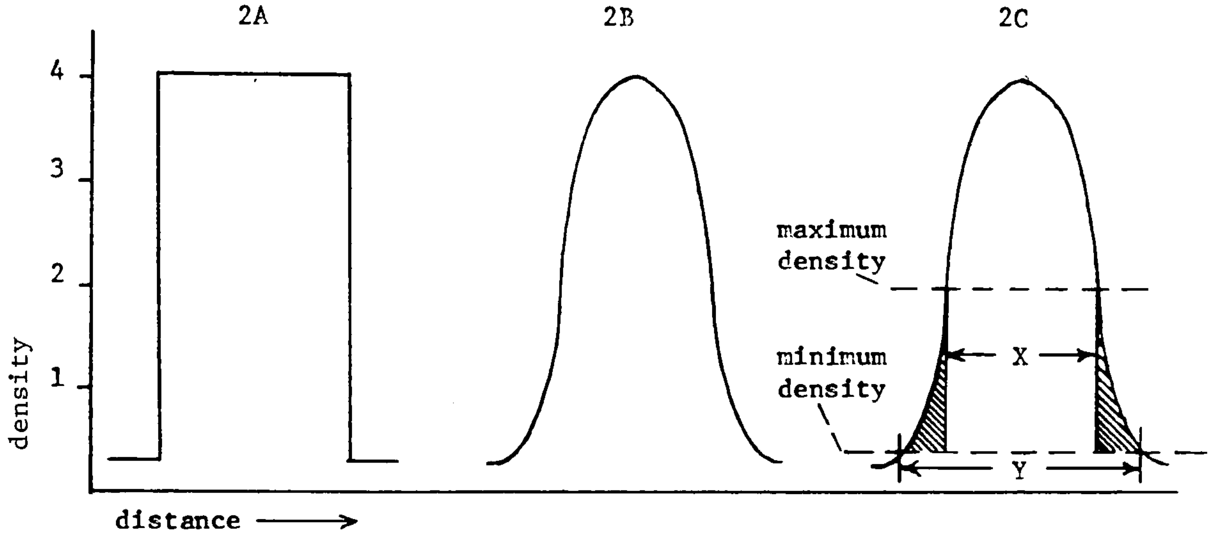



Fig.2. Halftone dot profiles

Fig.2A. Profile of ideal hard dot
Fig.2B. Profile of soft dot producing dot fringe
Fig.2C. Dot fringe (shaded area) produced at minimum and maximum cut-off densities (Y-X)

Aside from the possible differences in rapid access halftone screens and the resulting dot quality on a given exposure, film, and processing combination, three alternatives are possible when attempting to reduce excessive dot fringe. One possibility is to lower the processor temperature and speed, within limits, to improve dot sharpness. Another solution is to contact the halftone film onto a high contrast emulsion to harden the halftone dots. Both of these methods add time to the rapid access technique of halftone photography and thus diminish the advantage of speed. The third approach is to make the dots of the halftone image large enough to compensate for the amount of dot fringe lost during subsequent contacting to the printing plate. Necessary to determining the correct amount of compensation would be finding the correlation between the size of the dot before and after contacting to the printing plate. If this correlation could be determined, dot area aim points could be established for the first generation halftone films, thus insuring acceptable plate images and optimum process control in generating the halftone films.

Methods employed to evaluate dot size have many shortcomings, but are adequate for evaluating the harder, less fringed dot of lith films. Errors in dot area measurement by conventional evaluation methods are amplified when evaluating dot size on rapid access halftones. The simplest of methods, and perhaps the most used, is the use of an optical magnifier. Accuracy in determining dot percent is dependent solely on the skill and experience of the viewer. As Figure 3 illustrates, perceptions of viewers vary. The shaded area of the graph illustrates the

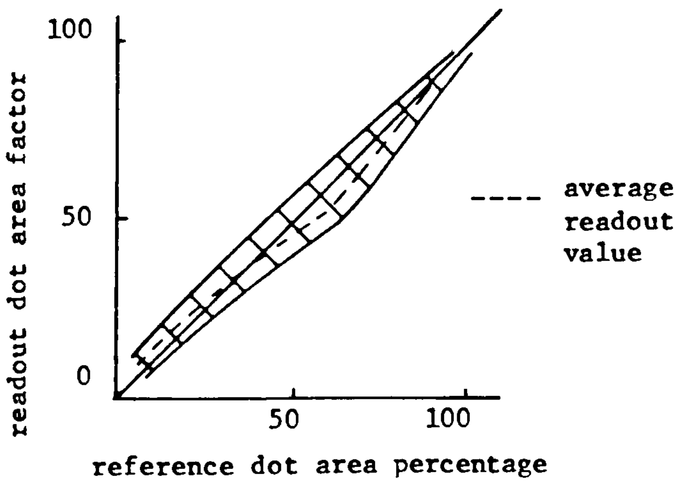



Fig.3. Distribution of dot area percentages visually determined with the aid of a loupe (taken from Graphic Arts Japan Vol.21, 1979-80)

total viewer deviation from the actual dot area percentage (solid 45° line). The broken line represents the average deviation from the actual dot area percentage. Of interest in the graph is that the maximum dispersion is found at the middle portion of the curve at the 50 percent dot area. Total deviation from the actual value can exceed 15 percent.

The use of dot area meters has widened. The major source of error of dot area meters, when measuring first generation halftones, is that their design assumes that transmittance and percentages of dot areas are in a linear relationship. However, the effect of dot fringe normally reaches the maximum level at around the 50 percent area.[5] Even after calibration of the instrument by compensating for Dmin and ghost dots, the effect of fringe and, thus, effective dot area can not be accurately determined.

Another approach to evaluating dot fringe and its effect on the effective printing density (the amount of density required to form dots on the printing plate) is to use dark field illumination. Dot fringe is most visible when the film is illuminated by 45° angle oblique

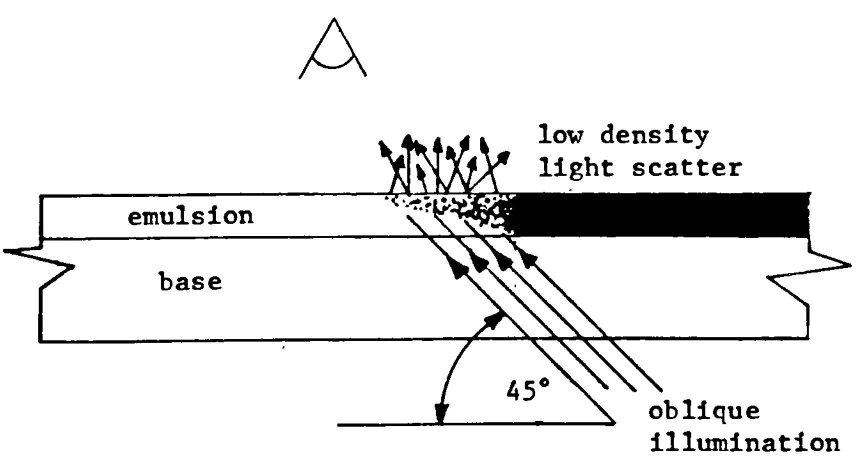



Fig.4. Viewing dot fringe by oblique illumination

illumination (see Figure 4). The amount of fringe can be visually identified due to the light scatter created when light is transmitted through the area and to the viewer.

Several different variations utilizing the concept of oblique illumination have been proposed. One such technique proposes the addition of an adjustable second source of illumination. With the proper balancing of the illuminators, the lower densities, which ordinarily absorb light, can be effectively eliminated, thus identifying the correct effective dot area.[6] Another technique introduces "differential-colored polarized light" to accentuate the differences in fringe and printable dot by displaying each as a different color.[7] These variations have either not been incorporated in an instrument design or have not been accepted by the graphic arts photographer.

The significance of the problem of compensation for dot fringe on rapid access halftones has been confirmed by both the manufacturers and users of rapid access materials. According to a publication by Beta Screen Corporation, "The key to making acceptable halftones with RA materials is to minimize soft dots and fringe at the dot edges in the initial step, and to compensate for the remaining deficiencies in the later steps."[8] A user of the rapid access process, Seymour Schwartz, writes:

> The halftones will look different than what you are used to: for instance, the shadow dots will show a star shape, but the points of the star will not plate. In the highlights a light star will also appear, again only the center section will plate. When a bump exposure is used, sometimes the highlights will appear veiled. Only the center section of this highlight dot will plate. To pick up a tiny highlight dot may, in extreme cases necessitate an increase in plate exposure of 30 percent or so.[9]

Dot fringe on halftone films processed by rapid access is unique to the process due to the cumulative effects of high film fog tendency, low Dmax, and a unique dot geometry produced by some rapid access screens. These effects along with the major factor of rapid access materials producing softer dots than lith due to its lower gamma of the film in the toe region of the characteristic curve, present a need for quantifying dot fringe to insure the correct evaluation of halftone films prior to subsequent contacting operations.

## Objectives and Hypotheses

The proposed research has two primary objectives. The first objective is to collect data to support the claim that there is substantially more dot fringe found on rapid access halftones than on conventional lith halftones. Although many statements found in the literature maintain this claim, quantifying data have not been published. Further, the intention is to illustrate that not only are there significant differences in the fringe characteristics of rapid access and conventional lith halftones, but that traditional methods of identifying the largest ghost dot and "zeroing" the dot area meter on this area will not compensate for dot fringe when measuring rapid access halftone films for effective dot area.

The second objective is to design a compensation method whereby a correlation between percent dot found on the rapid access halftone negative and the percent dot on the subsequent contact medium can be applied. Assuming that this relationship can be found, a calibration method or correction factors could be utilized, enabling films to be quantitatively evaluated according to established aim points for insuring process control.

To achieve the stated research objectives, the following hypotheses have been formulated and will be tested:

1. There are no significant differences between the halftone dot fringe characteristics of rapid access halftones and conventional lith halftones.

2. Conventional dot fringe compensation methods (zero referencing the densitometric instrument on the ghost dot) used on rapid access halftones are an accurate method for identifying the effective printing dot.

3. A compensation method to account for dot fringe will have no significant effect in identifying the effective dot area percent within established control limits.

Notes

[1]Viktor Tkacenko, "Where Rapid Access Suits Film Handling Needs," Printing Impressions 22 (November 1979): 8H.

[2]Jack R. Nussbaum and Edward C. Wozny, "Promising Future for Rapid Access Processing," Chemco Technical Bulletin #38: 4.

[3]Ibid., p. 5.

[4]Seymour Schwartz, "How to Get More Out of Your Contact Screens," [reprint Inland Printer, Printing Impressions, Graphic Arts Monthly, Canadian Printer & Publisher] Selecting Screens for Rapid Access (RA) Film Negatives and POS/POS Paper Positives.

[5]Yuji Mituhashi and Katsusuke Nagano, "Analysis and Study of Dot Area Percentages. Development of DOTTIE," Graphic Arts Japan 22 (1978-80): 73.

[6]Brent H. Archer, "Photometric Measurement of Dot Area," TAGA Proceedings (1966): 39.

[7]M. Tajima, Y. Komatsu and T. Miyauchi, "Techniques For Evaluating Dot Quality in Halftone Processes," Photographic Science and Engineering 8 (July/August 1964): 218.

[8]Schwartz.

[9]Rapid Access Contact Screens, Beta Screen Corporation (November 1980): 5.

# CHAPTER II

## Methodology

To test the first hypothesis, a visual comparison of both dot fringe and dot geometry will be conducted by using conventional and rapid access contact screens. A comparison between percent dot of the first generation films and percent dot of the contact films will be made.

To establish a visual comparison of each of the halftone dots, halftone films will be prepared for each of the two contact screens by placing an effective highlight dot in identical steps of the step tablet with a main exposure only. The effective highlight dot will be determined as the percent dot on the first generation film needed to yield a 95 percent dot area on the contact medium. In addition to identifying the effective highlight dot, the effective midtone (50 percent dot) and shadow (5 percent dot) will be used in the comparison. These three percent dot areas of the step tablet of the first generation halftone films will be microphotographed to illustrate the differences in the amount of dot fringe and geometry produced by the two types of halftone screens.

To further quantify the halftone dot fringe differences of rapid access and conventional lith halftones, microdensitometer traces will be taken from the two sets of soft dot films. Scans of the three identified highlight, midtone and shadow dot areas of the graduated step tablet, for both the rapid access and lith films, will illustrate the spread of the dot fringe. The width of the dot fringe for both sets of films will be determined by the distance "L" on the horizontal axis of the microdensitometer trace. The dot fringe width will correspond to the spread of densities from .20 to 1.0 above the fog and film base (refer to Figure 5). The shorter the distance "L," the sharper, less fringed the halftone dot.

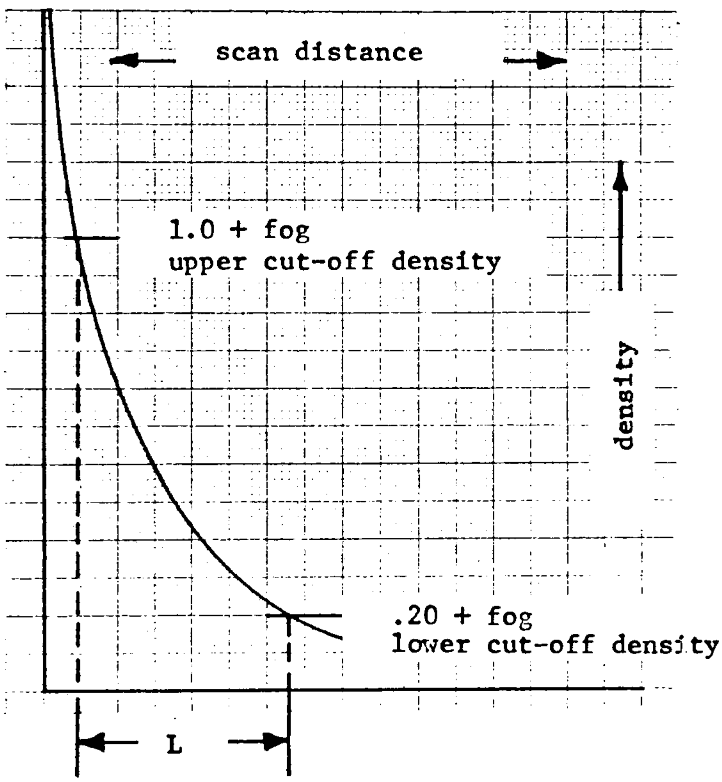



Fig.5. Microdensitometer trace of a halftone dot illustrating the spread of dot fringe

To further quantify the differences in fringe amounts of the two sets of halftone films for a given percent dot, the films used for the visual comparison will again be used. Five percent dot areas (95, 75, 50, 25, and 5 percent) will be measured from the two sets of contact films. One set of contact films will be prepared using an "under-exposure" condition. The second set of contact films will be prepared using an "over-exposure" condition. These exposure conditions will be based on a "normal" contact exposure found experimentally by the use of a continuous-tone gray scale. Differences between the under- and over-exposure films will be the equivalent of a shift of .30 density log exposure (double and one-half of the normal exposure).

These five percent dot areas of the two sets of contact films for rapid access and lith halftone film samples will be measured with a dot area meter after subtracting the film fog density. Differences in percent dot area between the over- and under-exposure contact films produced from the rapid access and lith halftone films will be determined. The first generation halftone film producing the greatest amount of difference between the two contact exposures will indicate a softer, more highly fringed halftone dot.

Testing the second hypothesis will be accomplished by using the conventional means of camera/screen/film calibration. Dark field illumination will be used to identify the largest ghost dot. The dot area meter will then be "zeroed" on this section of the film. A halftone exposure computer will be used to determine all halftone exposures based upon the calibration data collected in calibrating the system. A series of three halftones will be made with exposures exemplifying the limits of manipulation of the tone scale. This will be done in order to test for the effects of various halftone exposure conditions on dot fringe. These first generation halftone films will be evaluated by using a dot area meter adjusted to compensate for the ghost dot identified by dark field illumination. The halftone films will then be contacted and their corresponding percent dot area measured. All gray scales will be stripped onto a single carrier sheet. Contacting will consist of a single exposure onto a single piece of film. The hypothesis will be proven if there is no significant difference of percent dot area of the contact films compared to the percent dot area of the first generation films.

Testing of the third hypothesis will involve the design of a calibration system that will permit the extraction of percent dot area correction needed to achieve an effective printing dot when measuring first generation rapid access halftone films. Three first generation halftone films will be prepared having the following characteristics:

Film 1 Basic screen exposure placing a 95 percent effective printing dot in the highlight area of the gray scale.

Film 2 Calculated exposure from the Kodak Q-700* exposure computer based upon the longest highlight to midtone range (TR number) allowable.

Film 3 Calculated exposure from the Kodak Q-700 exposure computer based upon the shortest highlight to midtone range (TR number) allowable.

Calculated exposures for films 2 and 3 will be derived from the exposure computer after entering the calibration data found experimentally by following Kodak's recommended procedure. Three calibration films will be prepared according to the following requisites:

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*Kodak Q-700 is a programable exposure computer used to generate camera exposures based upon previously entered fixed exposure and processing conditions.

Film A Main exposure (imaged, screened exposure) yielding a 95 percent dot in the highlight area of the gray scale.

Film B Main exposure found from Film A plus a 10 percent highlighting exposure (no-screen, image exposure).

Film C Flash exposure (no-image, screened exposure) necessary to produce a 5 percent effective printing dot.

Percent dot area data taken from the first generation films will be plotted for each of the three exposure conditions, as density of the original gray scale versus percent dot of the reproduction.

Contact films will be prepared using the contacting procedure previously described. Percent dot area will be read on the identical density steps that were used in reading the first generation halftone films. This effective percent dot area data will then be plotted on the three graphs in which the first generation films were plotted.

A visual comparison will be made of the three dot area correction curves to determine if there are significant differences in the dot fringe produced under the varying test exposure conditions.

If significant differences in dot fringe produced by the auxiliary exposures (bump and flash exposures) are found, a dot fringe variability test will be conducted for the appropriate auxiliary exposure(s) producing the significant dot fringe differences in comparison to the main exposure only test film (Film 1).

Appropriate dot fringe variability tests will be conducted by selecting the auxiliary exposure necessary to produce the maximum effect as derived from the exposure computer. Successive graduated test films will be prepared, each produced by exposures representing a percentage of the maximum auxiliary exposure. For example, if it is found that a bump exposure produces a significant difference in dot fringe when compared to the main exposure only film, then a series of test films will be prepared with varying amounts of bump exposure. The first test film would be prepared by using the maximum bump exposure derived from the exposure computer by entering the shortest highlight to mid-tone range allowable. If, as an example, the maximum bump exposure is 50 percent, then five test films will be prepared using bump exposures ranging from 50 percent down to 10 percent.

The test films used in the dot fringe variability test will be contacted onto film to determine their effective printing dot. Both the first generation and the contact films will be measured to determine percent dot area. Percent dot area of the contact films will be subtracted from the percent dot area of the first generation halftone films. These percent dot area differences will be plotted together with the dot area differences of the main exposure only film.

The correction curves will be prepared by plotting the appropriate test films as percent effective dot (contact dot area film) on the abscissa versus percent dot area correction (contact film dot area less first generation dot area) on the ordinate.

Percent dot area correction factors will then be extracted by drawing intersecting perpendiculars at the 95, 50 and 5 percent dot area aim points from the appropriate correction curve. This data will then be used in all future dot area readings taken from first generation films produced under similar exposure conditions in order to determine effective dot area.

Several halftones will be processed utilizing the appropriate correction curve. The hypothesis will be rejected if, after contacting, the measured percent dot of the test gray scale exceeds the tolerance limits for each of the three aim points.

# CHAPTER III

## Literature Review

### Rapid Access Processing

Rapid access film processing, introduced just a few years ago, is gaining wider application in the graphic arts. The process was first introduced as a tray system for developing line negatives. Characteristically, a moderately high contrast film was exposed to high contrast copy and immersed in a pre-mixed, single solution developer. The induction period (time interval between the immersion of the film in the developer and the point at which the image begins to appear) was very short (approximately 5 seconds). Standard solution temperatures (68-72°F) were employed, along with the conventional minimum three chemical baths.

Rapid access processing does not utilize a monobath developer (i.e. diffusion transfer). In the context of this research, stabilization and diffusion transfer processing will not be considered rapid access processing. A machine is not necessarily required for rapid access processing, but with increasing demands in the industry for processing speed, the concept was incorporated into machine film processing. Rapid access processing is unique. It is not an accelerated lith system. That is, it is not a mechanical means utilizing high temperature processing with conventional lith developer and film, such as the so-called RAL, rapid access lith. To achieve higher throughput than lith machine processing, a combination of high temperature processing, fast processing emulsions and fast-acting developer constituents are combined in rapid access processing. Its use in the industry is found where an increase in contrast is not required. Rather, it is used to maintain the contrast that already exists, such as in line and contact work. For these conditions, a product of lower contrast may be used, but with a shorter processing time and correspondingly higher productivity; such a product is "rapid access."[1]

## Lith Development

Rapid access processing uses a non-infectious developer. In order to gain an understanding of how rapid access development is achieved, it is necessary to explain the difference between infectious and non-infectious developing solutions.

Typical of an infectious developer is a four part combination of developing agent, accelerator, preservative, and restrainer.

The purpose of a developing agent is to reduce the exposed silver halide grains to metallic silver. The reaction that occurs is an oxidation-reduction reaction. The developing agent must be active enough to reduce the silver halide grains exposed to light, but not so strong as to reduce the unexposed grains and cause the film to fog. Developing agents typically used in graphic arts developers are organic compounds that are derivatives of benzene. The most common infectious developing agent is hydroquinone.

The accelerator controls the alkalinity of the developing solution. Developing agents are more active in alkaline solutions. Basic compounds with a high pH (approximately 9.0-12.0), such as sodium carbonate, are very active and are common in infectious developers. The accelerator also neutralizes the acid that is formed during development, preventing the solution from becoming acidic.

A preservative (sodium sulfite) reduces the effect of aerial oxidation on the developing agent.

A restrainer (potassium bromide) is commonly added to reduce the amount of fog formation. The bromide ions of the potassium bromide surround the unexposed silver halide grains, thus limiting the effect of the developer on the silver ions in reducing them to metallic silver.

Infectious developers are packaged in two solutions. Commonly, one solution contains the developing agent and the preservative. The second solution contains the accelerator and the restrainer. The two solutions are combined when added to the processor. Without this packaging arrangement, the developer slowly loses its activity due to chemical oxidation.

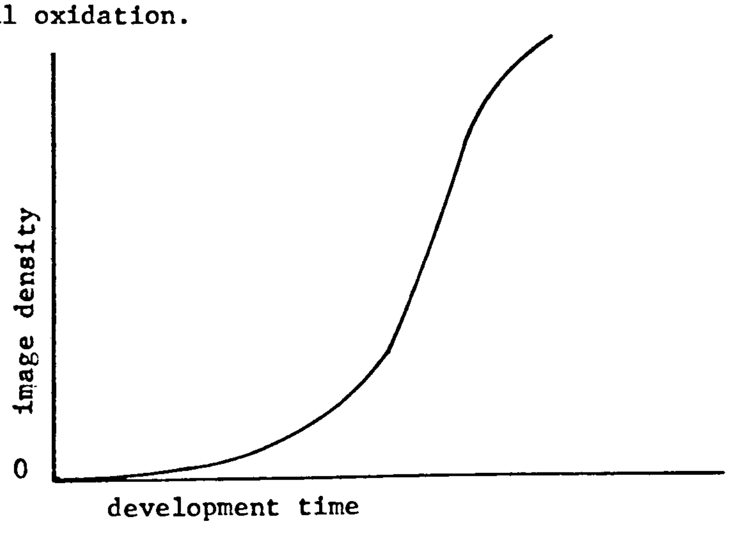
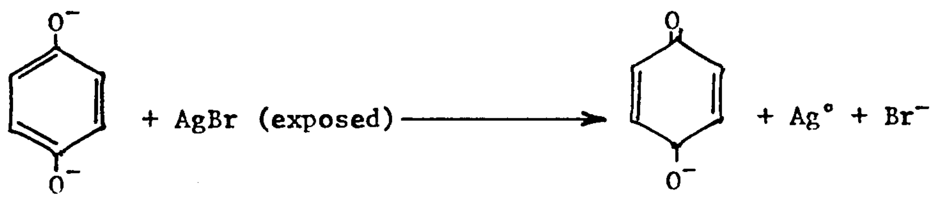



Fig.6. Relative density producing characteristics of an infectious developer as a function of development time (taken from Chemistry for the Graphic Arts)

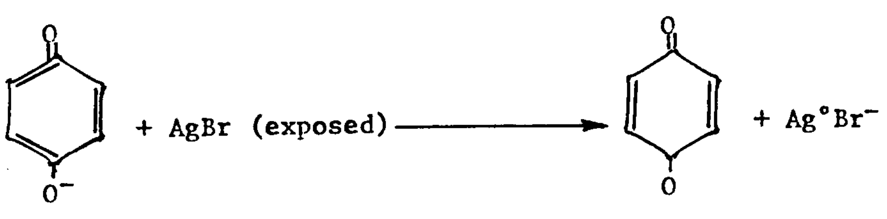
High contrast images are created by the "lith effect" or infectious development. Characteristics of lith developers are relatively long induction periods and a sharp increase in contrast after the induction period (see Figure 6). The lith effect is summarized as follows:

Hydroquinone ions react with exposed silver bromide, the silver bromide is reduced to metallic silver, and the hydroquinone is oxidized to semiquinone:



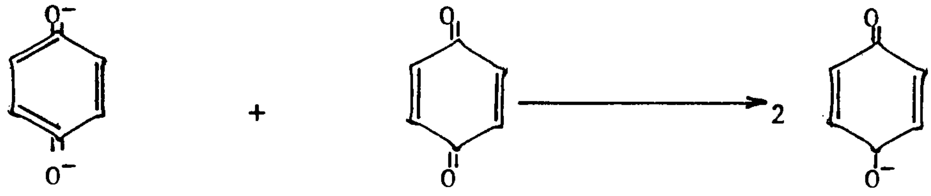

hydroquinone ion semiquinone ion

With an increase in the activity due to the semiquinone ions, reduction of the silver halide accelerates as semiquinone is oxidized to quinone:



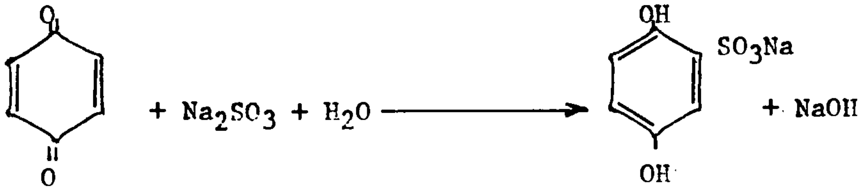

quinone

The quinone reacts with more hydroquinone ions to form more semiquinone:



This reaction produces the infectious effect. This chain reaction can be repeated many times and is limited only by the quantity of hydroquinone and reducible silver in a given location.

The preservative, sodium sulfite, reacts with the quinone to form hydroquinone monosulfonate:



The degree to which this reaction takes place partially stops the infectious effect. Thus, the amount of sodium sulfite is critical in reducing aerial oxidation. The control of aerial oxidation is often aided by the addition of a buffering agent such as sodium formaldehyde bisulfite. In an alkaline solution, a small amount of this buffering agent dissociates to form sodium sulfite and formaldehyde:

$$NaOH + H\text{-}\underset{H}{\overset{OH}{C}}\text{-}SO_3\ {}^{-}Na^{+} \longrightarrow \underset{H\quad H}{\overset{O}{\overset{\|}{C}}} + Na_2SO_3 + H_2O$$

sodium formaldehyde bisulfite — formaldehyde

As the sodium sulfite is consumed in the reaction, more of the buffering agent dissociates to provide more sodium sulfite.[2]

To conclude, an infectious developer is characteristically one in which hydroquinone, which is sensitive to pH and bromide ion concentration, is the primary developing agent. The concentration of sodium sulfite is quite low, allowing the survival of the semiquinone ions, and a sulfite buffer is used to control the sulfite concentration. Due to the low level of sodium sulfite, the developer is subject to aerial oxidation. As a result, replenishment is critical in achieving the proper developer activity and gradient, and thus, chemical stability. Lith developers provide very high contrast due to the hydroquinone developing agent and low sulfite concentration.

## Rapid Access Development

Unlike infectious development, which increases the density difference between different exposure levels, non-infectious developers produce densities in proportion to exposure.[3] The primary chemical differences in non-infectious developers are the higher concentration of sodium used as the preservative, and the addition of auxiliary developing agents, such as metol and phenidone, to hydroquinone in forming the developing agent. These non-infectious developers are often referred to as "MQ" or "line" developers.

With the addition of metol as an auxiliary developing agent and the increase in developer temperature (in excess of 100°F), the effect is a shortened induction period and, consequently, a greatly reduced development time (see Figure 7).

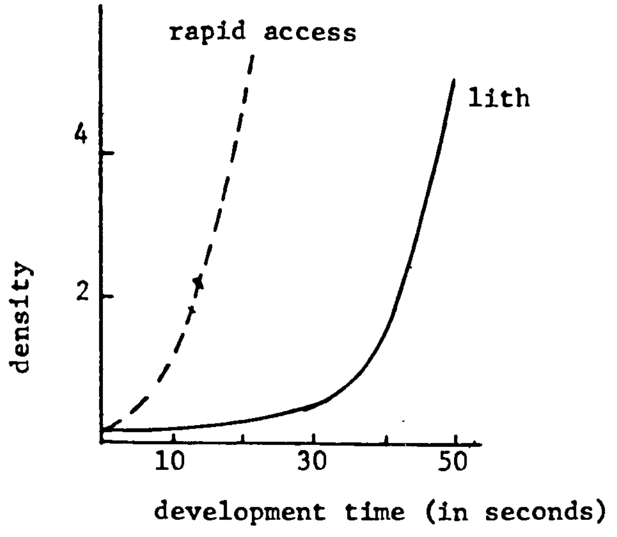



Fig.7. Differences in induction period and development time between rapid access and lith (taken from Chemco Technical Bulletin #38)

Due to the shortened induction period, the contrast of the resulting image of the non-infectious developer is less than images produced by infectious development.

With the addition of metol as a developing agent, what is lost in film contrast is gained in processing speed and latitude. Processor design can be simplified and developer activity does not require constant monitoring. Typically, the developer is considered exhausted when the Dmax of the film drops to an unacceptable level.

Rapid access developers, characteristic of continuous-tone chemistry, have a high sulfite concentration. Higher sulfite concentrations prevent infectious development by diminishing the growth of the highly active semiquinone ions. With this increase in sulfite concentration, contrast is decreased and chemical stability increased.[4]

High developer temperatures and the addition of metol increase the film's tendency to fog. To reduce this fogging tendency, a special restrainer is added to the developer. Excessive film fog is particularly detrimental to holding highlight dots open and clear when producing first generation halftone films made from special rapid access halftone screens.

Coupled with the chemical differences of rapid access and lith development are the sensitometric differences illustrated by their respective characteristic curves (refer to Figure 8).

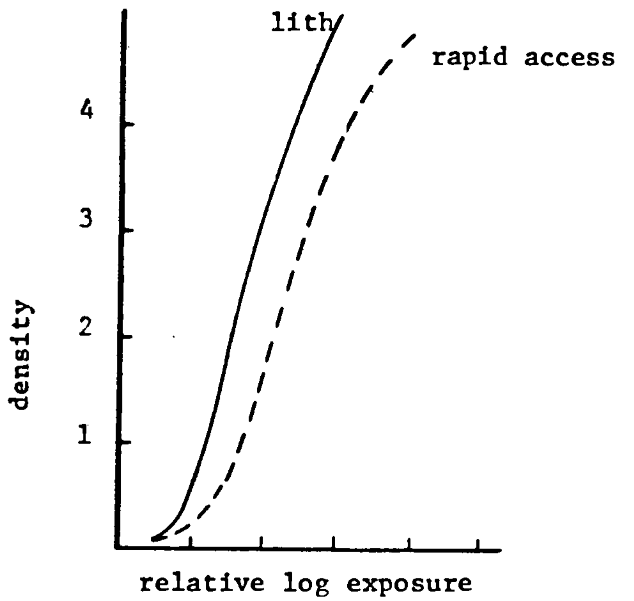



Fig.8. Comparitive characteristic curves of lith and rapid access films (taken from Chemco Technical Bulletin #38)

The contrast qualities resulting from exposure of the two films to continuous-tone images are related to the long, sharply rising section of the response curve. The slope of the straight line portion of the curve expresses the gamma, or contrast, of the film and processing conditions. Differences in the gamma of the two films may not be significant and thus not necessarily the prime reason for rapid access film being inappropriate for screening applications.[5] Although the loss of contrast typical of rapid access films does have an effect on the tone rendering capabilities of the system, the capability of a developer to produce dense, sharp halftone dots on a film is primarily effected by the shape of the characteristic curve in the toe region.[6] As can be seen in Figure 8, lith film has a sharp response in the toe section of the curve. Density remains constant at low exposure levels until there is a sharp increase in density giving the toe region a "flat" shape. The flat toe section of the characteristic curve for lith developers provides a sharp drop off in density at the edges of the halftone dots. Rapid access processing, however, has a more gradual increase in density in the toe region of the curve. The resulting effect on the halftone dot structure is at the edges of the dot where the changes in film exposure from point to point are more gradual. Consequently, the edges of the dot are less sharp (more blurred).[7]

## Rapid Access Contact Screens

The cumulative effects of non-infectious development at high temperatures and short induction periods on moderately high-contrast films exposed to continuous-tone copy through a conventional contact screen produce a reduction of density and edge gradient. As a result, films exhibit overall excessive dot fringe, gray shadow dots, and veiled highlight dots, which, when exposed directly to a printing plate, produce inferior images.

Initially, compensation for the problems of dot sharpness and highlight veiling was attempted by designing contact screens that provide a higher density dot and thus, in effect, a longer screen range.

Although such screens provided improvements in the tonal gradation of the halftone image, they did not solve the fundamental problem of dot sharpness.[8] It became evident that what was needed was a contact screen designed in such a way as to adjust for these soft dot problems, particularly in the highlight and shadow dots.

In 1980, several contact screen manufacturers introduced a new rapid access contact screen. The new contact screens were not made from master glass screens, but rather each was a master screen made onto the contact screen film.[9] Consequently, according to the many cited claims found in the literature, the vignetted density pattern exposed to the film had a density profile that could be more precisely controlled. Rapid access screens are truly negative-working in the shadow area and, in the highlight area, more positive-working characteristics are maintained.[10] The density profile of the rapid access contact screen is illustrated in Figure 9.

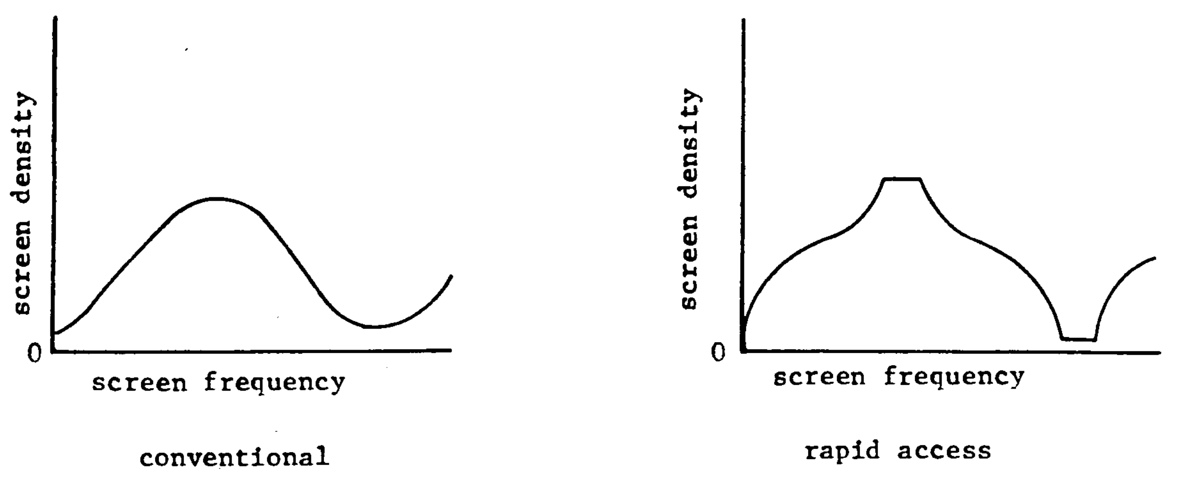



Fig.9. Comparative contact screen density profiles (taken from American Printer & Lithographer, September 1980)

Reflected light modulating through the rapid access contact screen produces a small, high density shadow dot. Due to the sharp density gradient of the screen, the halftone dot increases in density at a proportionally greater rate than dot size.[11] This same high density gradient in the highlight area keeps the highlight dots open and decreases veiling. Halftone dots produced from some rapid access screens have a characteristic star shape. The points of the star-shaped dots lack density compared to the high density center core.* When contacting to a printing plate, the shadow and highlight dots will be seen as hard, relatively sharp dots, but the low-density star tips will be lost in the contact plate exposure.[12]

## Halftone Dot Area Measurement

In conventional lithography, black and white continuous-tone images are reproduced by using the halftone technique. Tones of the reproduction are expressed in terms of percent dot area. Consequently, the control of this dot area is a factor in maintaining high quality throughout the printing process. In order to control dot area, one must first quantify it. Dot area measurement of rapid access halftones presents greater problems than measurement of lith halftones. Rapid access halftones have a particular set of dot characteristics that must be identified and compensated for in order to insure consistent quality and repeatability.

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*Microphotographs and microdensitometer traces of the conventional and rapid access contact screens used in the experiment are found in Appendix D.

Dot area measurement of first generation halftone films is performed by using either a transmission densitometer and converting integrated density to percent dot area, or a dot area meter in which this conversion process is incorporated into the machine design. When measuring hard dots (no fringe) only, the base plus fog density of the film must be compensated for. Either measurement method would prove accurate once the base plus fog density of the film is subtracted from the transmittance. When measuring soft dots on first generation halftone films, only the areas where there is sufficient density to block light transmission will form the dot. This density is referred to as the effective printing density. The resulting dot area is the effective dot area percentage. Accurate measurement depends largely upon the evaluation of the fringe area. Thus, it is necessary to not only subtract the base plus fog density of the film (Dmin), but also the amount of fringe density that will be lost in the film's exposure to a printing plate. The amount of compensation necessary to establish the effective printing density is determined by identifying the largest dot that, when contacted to the printing plate, will not register as an ink-receptive image. This dot structure is referred to as a ghost dot. The ghost dot can be identified by either dark field illumination or by plate exposure and subsequent printing press reproduction. Once this ghost dot has been identified on the halftone film, this area is placed under the densitometer or dot area probe and the instrument is adjusted linearily to read "0" integrated density or percent dot area. As mentioned previously, this method assumes that there is a linear relationship between transmittance and percent dot area. However, the largest amount of dot fringe is found near the 50 percent dot area.[13]

Several variations on the concept of oblique illumination have been proposed to identify dot fringe. One such technique proposes the addition of an adjustable second source of illumination. With the proper balancing of the illuminations, the lower densities, which ordinarily absorb light, can be effectively eliminated, thus identifying the correct effective dot area.[14] Another technique introduces "differential-colored polarized" illumination to accentuate the differences in fringe and printable dot by displaying each as a different color.[15] Devices employing these variations either have not been incorporated in an instrument design or have not been accepted by the graphic arts industry.

## Rapid Access Halftone Dot Characteristics

The unique dot structure of rapid access halftones makes the task of measuring the effective printing dot by conventional instrumentation and procedures even more critical and, consequently, less accurate. There are three halftone dot characteristics of rapid access halftones that add to the difficulty of accurately measuring the effective percent dot. Perhaps the most obvious of the three characteristics is dot geometry. The dot has a definite star shape with four pointed corners. Its shape is similar to an elliptical-shaped dot, but more exaggerated. This shape is most evident from the midtones to the shadows. As a result of this dot shape, the corners of the dot, due to their sharpness, have a tendency to be lost when contacted to a printing plate. Also, from a visual evaluation standpoint, dot shape effects dot area and effective dot percent.[16] Second, due to the lower film Dmax, particularly in the shadow dots, the effective printing density is difficult to establish. The use of dark field illumination to visually show dot fringe, and, therefore, reproducible dot size, may be inconclusive. The quality of dot may appear poor on the shadow box (dark field illuminator), but may hold perfectly well on contacts and platemaking.[17] Third, film fog is found at the highlight end of rapid access halftones. Present is a proportionally higher amount of low density fog in the small highlight dots than what can be attributed to the film's Dmin. Also called highlight dot veiling, the condition makes it difficult to evaluate the effective percent dot in the highlight areas. How much this small highlight dot will "open up" after subsequent contacting is difficult to estimate or measure.

# NOTES

[1]Arthur Lilley, "The Pursuit of Contrast," Australian Lithographer, Printer & Packager 12 (1979): 18.

[2]Paul J. Hartsuch, Chemistry for the Graphic Arts (Pittsburg: Graphic Arts Technical Foundation, 1979), pp. 108-109.

[3]Ibid., p. 113.

[4]Chemco Technical Bulletin #38, "Promising Future for Rapid Access Processing," p. 3.

[5]Ibid.

[6]Ibid.

[7]Ibid.

[8]Information Guide, "Rapid Access Contact Screens," Beta Screen Corporation, p. 4.

[9]Elizabeth Cunningham, "With Rapid Acess Line and Halftone Screens Acceptable Quality is Possible," American Printer & Lithographer (September 1979): 68.

[10]Ibid.

[11]Ibid.

[12]Ibid.

[13]Yuji Mitsuhashi and Katsusuke Nagano, "Analysis and Study of Dot Area Percentages--Development of DOTTIE," Graphic Arts Japan 22 (1979-80): 74.

[14]Brent H. Archer, "Photometric Measurement of Dot Area," TAGA Proceedings (1966): 38.

[15]M. Tajima, Y. Komatsu and T. Miyauchi, "Techniques for Evaluating Dot Quality in Halftone Processes," Photographic Science and Engineering 8 (July/August 1964): 218.

[16]The Contact Screen Story (Wilmington: E.I. DuPont De Nemours & Co., 1972), p. 94.

# CHAPTER IV

## Experimental Results

### --Section A--
### Comparison of Dot Fringe Characteristics of Rapid Access and Conventional Lith Halftones

The illustration of the differences in fringe characteristics of rapid access and conventional lith halftones was determined visually by the use of microphotographs and quantitatively by microdensitometer traces and film contacting. Sample film preparation and film contacting data are listed in Appendix A1 and A2 respectively.

#### Microphotographs

Microphotographs were taken of the two film samples. The two film samples are first generation halftones imaged with a main exposure only.

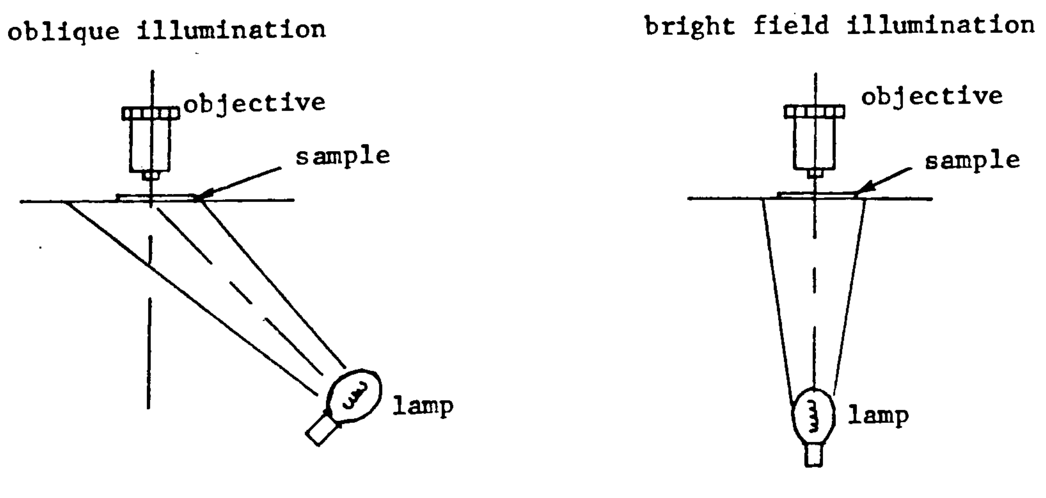


Fig. 10. Principles of the two types of sample illumination for the microphotographs

The samples were photographed directly onto a Poloroid continuous-tone material at a magnification of 160X. Intensity of the light source, angle and distance were held constant for each characteristic comparison. Two types of sample illumination were used (refer to Figure 10).

Presented in Figure 11 are microphotographs of 50 percent dot areas of each sample. The upper photographs were illuminated with bright

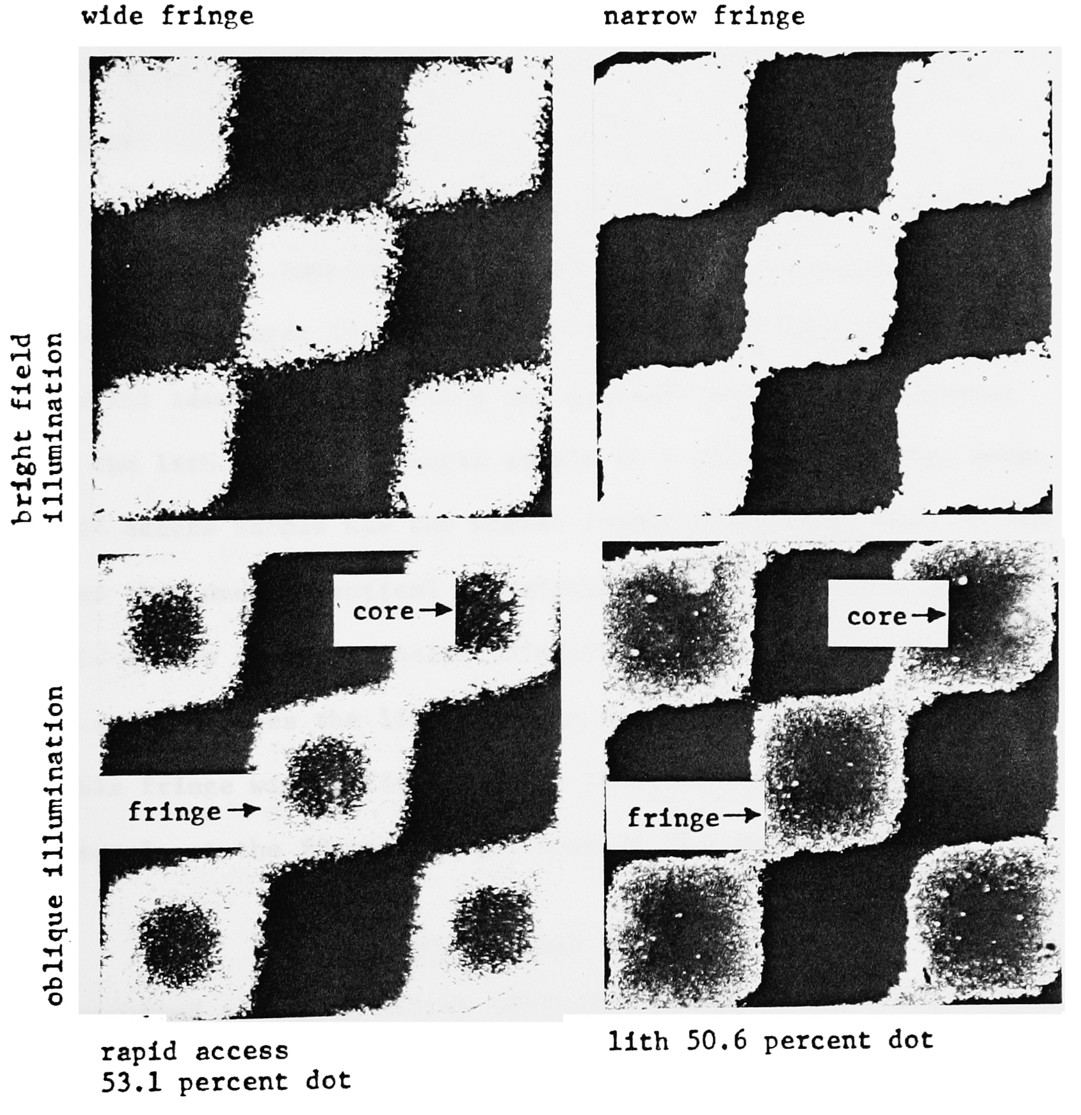


Fig. 11. Microphotographs of approximate 50 percent dot area of rapid access and lith halftones illustrating differences in fringe widths

field illumination. The lower photographs were illuminated with oblique illumination, where the width of the light area surrounding the darker core of the halftone dot is representative of the dot fringe. The lower left photograph of the rapid access halftone dots shows a wider fringe width than does the lower right photograph of the conventional lith halftone dots.

Presented in Appendix A3 are microphotographs of shadow and highlight dots of the two samples taken with oblique illumination.

Visual differences in fringe are most prevalent at the 50 percent dot area. As the halftone percent dot area increases from the midtone area of the samples, the visual effect is diminished, and at the highlight dot area (95 percent) negligible with both samples.

In all cases where halftone dot contrast variation is present in both the lith and rapid access sample at a given percent dot area, the rapid access sample has the widest fringe area. Therefore, it can be stated that under identical illumination and exposure conditions, the rapid access sample visually illustrates a softer, more highly fringed dot than does the lith halftone sample. In addition, the comparable fringe width effect is most pronounced with the rapid access sample at the 50 percent dot area of the sample.

## Rapid Access Halftone Dot Geometry

Presented in Figure 12 are microphotographs of the dot geometry characteristics of the first generation halftone film and its second generation film contact.

A general observation of the rapid access first generation film

88.3 percent first generation halftone dot

75.0 percent second generation contact dot

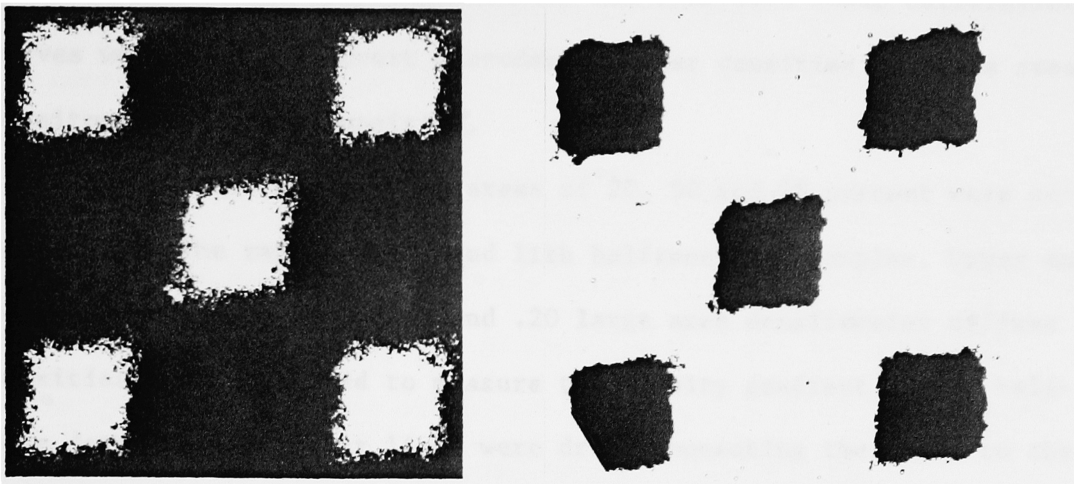

Fig.12. Dot geometry characteristics of a rapid access first generation halftone dot and its second generation contact dot

is that it has a definite triangularly pointed star shape. More specifically, when comparing the first generation contact dot, the sharp, triangularly pointed corners of the first generation dot lose their sharp, pointed shape when contacted to film. The contacting affects the geometry of the dot, but more importantly, creates a loss in visual percent dot area. As a result, visual determination of the dot area by the use of an optical magnifying glass (loupe) of a first generation rapid access halftone dot would involve more critical judgement than a first generation conventional halftone dot.

## Microdensitometer Traces

A further comparison of the differences in dot fringe between rapid access and lith halftone films was conducted by making microdensitometer traces of the selected equivalent percent dot areas of the sample films. Microdensitometer set-up and operation data are supplied in Appendix A4. Located in Appendix A5 are calibration curves for each period the microdensitometer was operated. These calibration curves were used to convert microdensitometer densities to large area densitometer diffuse densities.

Approximate percent dot areas of 20, 50, and 80 percent were selected from the rapid access and lith halftone film samples. Upper and lower cut-off densities (1.0 and .20 large area densitometer diffuse densities) were selected to measure the density gradient of the halftone dots. Perpendicular lines were drawn connecting the upper to the lower cut-off densities. The distance of the perpendicular to the lower cut-off density was measured in microns (refer to Figure 5).

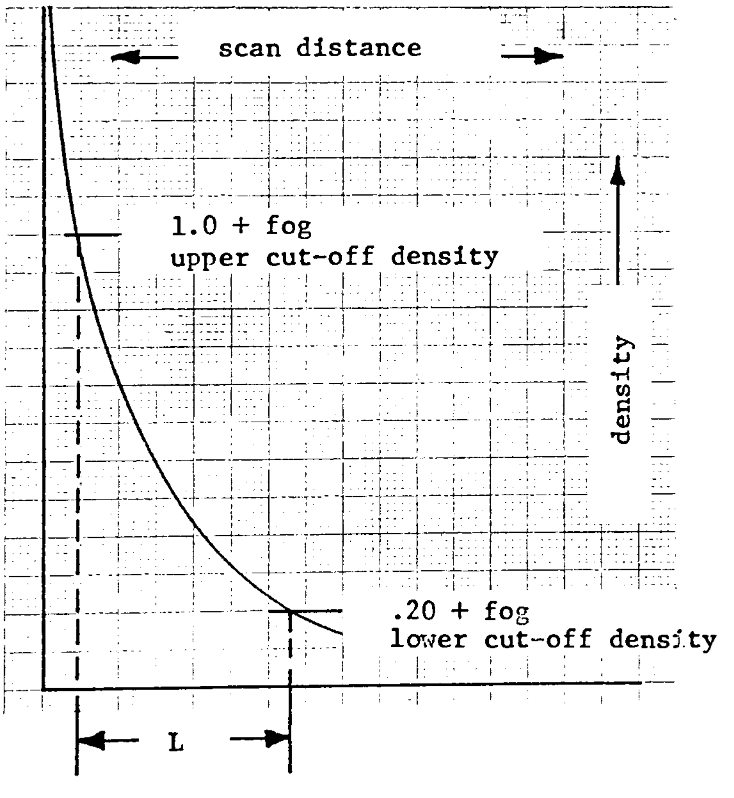


Fig.5. Microdensitometer trace of a halftone dot illustrating the spread of dot fringe

This distance was measured on each side of the halftone dot trace and averaged. The shorter the distance in microns from the intersecting perpendicular to the lower cut-off density, the sharper, less fringed, the halftone dot.

In order to average local irregularities, a composite trace was drawn from the actual traces of the three different halftone dots from each sample scanned. Presented in Appendix A6-A are the composite traces. The actual traces are located in Appendix A6-B. Data derived from the composite traces are presented in Table 1 below.

TABLE 1

MICRODENSITOMETER TRACE DATA ILLUSTRATING DIFFERENCES IN MICRONS OF DOT FRINGE WIDTH OF RAPID ACCESS AND LITH HALFTONES AT SELECTED CUT-OFF DENSITIES

| Measured Effective % Dot Area | Fringe Width Right Side of Dot | Fringe Width Left Side of Dot | Average Dot Fringe Width | Difference Dot Fringe Width | Dot Width Ratio |
|---|---|---|---|---|---|
| 21.7% Lith | 5.0 | 5.0 | 5.0 | | |
| 24.3% R.A. | 8.75 | 10.0 | 9.375 | 4.375 | 1.9 |
| 50.6% Lith | 6.25 | 5.0 | 5.625 | | |
| 53.1% R.A. | 11.25 | 10.0 | 10.625 | 5.0 | 1.9 |
| 79.5% Lith | 3.75 | 5.0 | 4.375 | | |
| 84.6% R.A. | 7.5 | 8.75 | 8.125 | 3.75 | 1.9 |

The results of the microdensitometer traces indicate there are differences in edge gradient of the two types of halftone dots between the selected cut-off densities. In all cases, regardless of the dot size evaluated, the rapid access dot has a less sharp edge gradient or wider fringe width. Secondly, expressed as a ratio, the average fringe width of the rapid access dots has a two-to-one increase in width compared to the lith dot fringe width.

## Film Contacting

To quantify the differences in fringe amounts between the two halftone film samples, percent dot area differences were determined for each of the two films by comparing the equivalent dot areas of the first generation films to those of the contacted, second generation films. The test films used in the microphotographs were again used to illustrate this difference.

Three different contact test exposures were used in the test. First, a "normal" test exposure was determined. This normal exposure was selected on the basis of the exposure time yielding the same cut-off density as a printing plate using the continuous-tone gray scale segment of the original UGRA* Plate Control Wedge. This normal exposure was doubled to give an "over-exposure" condition and reduced by one-half giving an "under-exposure" condition. This method, in effect, defines the density boundaries (.6-1.2) of the halftone dot fringe. As a result, the exposure range represented a log exposure shift of .30 in density. A summary of the data is presented in Table 2. Complete contact percent dot area data for the rapid access and lith samples is located in Appendix A7-A and A7-B. Located in Appendix A7-C is the graph used to determine the equivalent effective percent dot areas listed in Table 2.

The results from Table 2 indicate the lith first generation halftone film has a harder, less fringed dot. It is assumed that the

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*Swiss Association for the Promotion of Research in the Graphic Arts Industry.

TABLE 2

FRINGE DIFFERENCES BETWEEN RAPID ACCESS AND LITH FIRST GENERATION HALFTONE FILMS AT AN OVER-EXPOSURE AND UNDER-EXPOSURE CONDITION

| | Equivalent Effective Percent Dot Area | | | | | |
|---|---|---|---|---|---|---|
| | 95% | 75% | 50% | 25% | 5% | Average % Difference |
| Rapid Access Over less Under-Exposure | 3.2 | 11.3 | 9.8 | 6.2 | 7.0 | 7.5 |
| Lith Over less Under-Exposure | 1.2 | 3.2 | 5.2 | 3.6 | 2.5 | 3.1 |
| Percent Difference | 2.0 | 8.1 | 4.6 | 2.6 | 4.5 | 4.4 |

hardest dot from the first generation halftone films would yield the smallest difference in percent dot area when the percent dot area of the over-exposed contact film is subtracted from the percent dot area of the under-exposed contact film. Expressed as an average value, this comparison test agrees with the microdensitometer traces in that the rapid access sample has approximately twice the percent dot area difference over the lith sample. Table also gives a comparison of percent dot differences in terms of where the differences appear on the halftone scale. Expressed in quarter tones, the largest percent dot differences are found at the 75 percent area of the halftone scale, followed by 50 percent dot area and the least differences at the 95 percent area.

An attempt was made to further investigate fringe differences between the two samples throughout the halftone scale. Presented in

Table 3 are dot area readings taken from the UGRA hard dot scale derived from contact films exposed under identical conditions of the rapid access and lith films.

TABLE 3

CONTACT PERCENT DOT AREA OF THE UGRA HARD DOT SCALE PRODUCED BY OVER, NORMAL AND UNDER-EXPOSURE CONDITIONS

| Original Percent Dot | % Dot Over-Ex. | % Dot Normal Ex. | % Dot Under-Ex. | Over-Ex. less Under-Ex. |
|---|---|---|---|---|
| 5.1 | 97.8 | 97.2 | 96.9 | .9 |
| 7.8 | 95.3 | 94.2 | 93.5 | 1.8 |
| 14.0 | 90.1 | 88.8 | 87.4 | 2.7 |
| 24.5 | 80.8 | 79.0 | 77.4 | 3.4 |
| 34.2 | 72.5 | 70.2 | 68.2 | 4.3 |
| 44.4 | 62.4 | 60.1 | 57.8 | 4.6 |
| 55.6 | 51.4 | 49.0 | 46.6 | 4.8 |
| 66.8 | 39.1 | 37.0 | 35.2 | 3.9 |
| 76.0 | 28.6 | 27.1 | 25.6 | 3.0 |
| 86.0 | 17.5 | 16.1 | 15.1 | 2.4 |
| 91.8 | 10.9 | 9.9 | 9.1 | 1.8 |
| 95.4 | 6.7 | 5.9 | 5.4 | 1.3 |

The data from Table 3 indicates that first there are differences in percent dot area from the over- and under-exposure conditions, and second, that these differences are most pronounced in the midtone area of the scale. It can be postulated that the differences can be attributed to, in the first case, light scatter within the film during contacting, and dot gain from light spread as it exits the first generation film original and strikes the contact film. The pronounced differences in percent dot area at the midtone areas illustrate the concept of "midtone jump." Due to changes in contact exposure time, the dot chaining which occurs at the midtone area of the scale is significantly more susceptible to percent dot area changes than the highlight and shadow areas of the halftone scale. Changes in the amount of chaining or dot connecting at the midtone areas have a dramatic effect on the integrated dot area readings.

In order to reduce error due to these contacting effects and to obtain a more accurate value representing dot fringe of the rapid access and lith sample films used in the comparison, the data from Table 3 of the hard dot UGRA scale was used to plot a calibration curve for the rapid access contacting system (refer to Figure 13). Percent hard

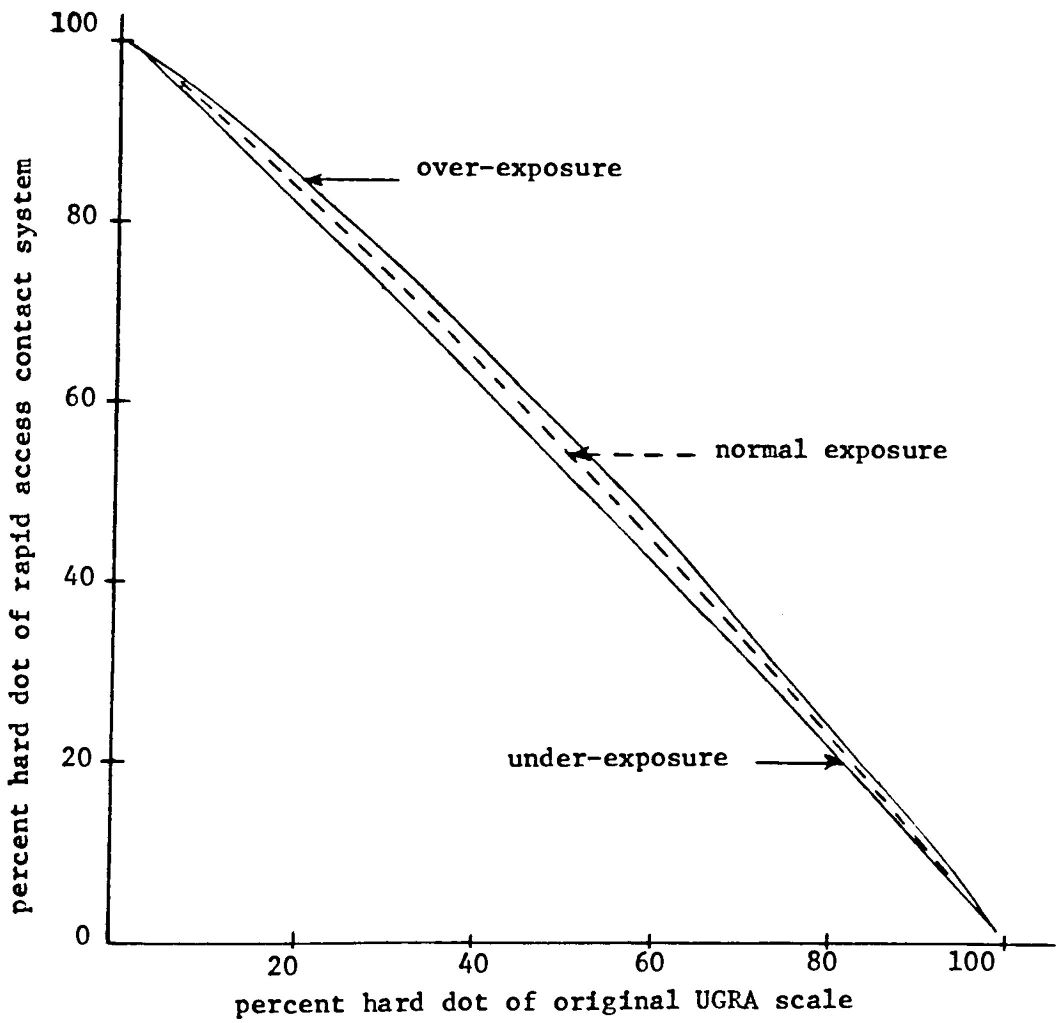


Fig.13. Rapid access contact system calibration curve

dot of the original UGRA scale was plotted with the percent dot area of the rapid access contact film for the three exposure conditions of under-, normal and over-exposure.

Presented in Table 4 are the "corrected" percent hard dot areas of the rapid access and lith contact films. The corrected percent hard dot areas were determined by locating on the abscissa (percent hard dot of the original UGRA scale) the percent dot area of each of the three exposure conditions of the contact films, tracing up to the appropriate calibration curve (under-, normal and over-exposure), and locating on the ordinate the equivalent percent hard dot of the contacting system for the contact films made from the lith and rapid access first generation halftone films.

TABLE 4

CORRECTED CONTACT PERCENT HARD DOT AREAS FOR RAPID ACCESS AND LITH HALFTONE FILM SAMPLES PRODUCED BY OVER, NORMAL AND UNDER-EXPOSURE CONDITIONS

| RAPID ACCESS | | | | LITH | | | |
|---|---|---|---|---|---|---|---|
| Over | Normal | Under | Over less Under | Over | Normal | Under | Over less Under |
| 97.0 | 97.4 | 99.0 | 2.0 | 97.8 | 98.2 | 98.0 | .2 |
| 96.3 | 97.0 | 98.1 | 1.8 | 96.2 | 97.3 | 97.6 | 1.4 |
| 93.3 | 93.8 | 94.7 | 1.4 | 93.7 | 93.7 | 93.7 | 0.0 |
| 90.3 | 91.3 | 92.3 | 2.0 | 87.8 | 88.2 | 88.2 | .4 |
| 86.3 | 88.2 | 89.6 | 3.3 | 81.5 | 81.7 | 81.2 | -.3 |
| 75.6 | 78.6 | 82.6 | 7.0 | 76.0 | 75.5 | 75.2 | -.8 |
| 64.2 | 67.6 | 71.3 | 7.1 | 69.7 | 69.6 | 69.3 | -.4 |
| 54.4 | 57.0 | 59.8 | 5.4 | 61.7 | 61.9 | 61.8 | .1 |
| 46.3 | 49.4 | 50.8 | 4.5 | 53.4 | 53.0 | 53.8 | .4 |
| 38.3 | 40.6 | 42.3 | 4.0 | 45.0 | 45.5 | 45.8 | .8 |
| 31.7 | 33.6 | 35.3 | 3.6 | 37.0 | 37.0 | 38.2 | 1.2 |
| 26.2 | 27.0 | 29.4 | 3.2 | 28.0 | 28.0 | 28.6 | .6 |
| 19.3 | 20.8 | 22.7 | 3.4 | 16.7 | 17.0 | 17.7 | 1.0 |
| 5.3 | 8.6 | 12.0 | 6.7 | 7.5 | 7.8 | 9.5 | 2.0 |

Corrected differences in percent dot area of the two samples found by subtracting the over-exposure corrected percent dot area from the under-exposure corrected percent dot area are also listed in Table 4.

These corrected percent dot areas for the rapid access and lith film samples were plotted as percent hard dot equivalent for the normal exposure versus percent dot area of the over- less the under-exposure difference (refer to Figure 14 illustrating the dot fringe profile of the two halftone film samples).

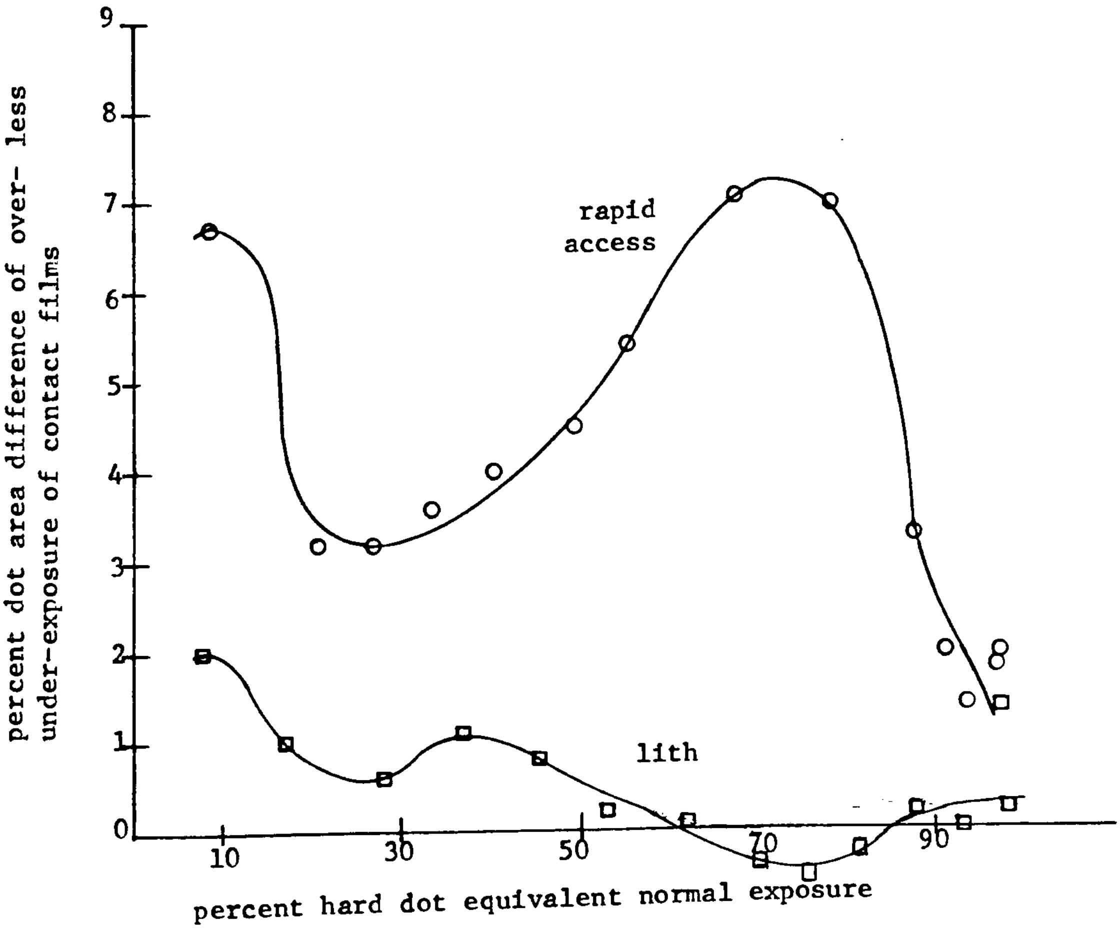


Fig. 14. Corrected dot fringe profile of rapid access and lith halftone film samples

Percent dot area differences of the rapid access and lith contact films at equivalent percent dot areas were extrapolated from Figure 14 and are supplied in Table 5.

TABLE 5

CORRECTED EQUIVALENT CONTACT PERCENT HARD DOT AREA DIFFERENCES BETWEEN RAPID ACCESS AND LITH HALFTONES

| Equivalent % Hard Dot Area | R.A. Over less Under Ex. | Lith Over less Under Ex. | Percent Dot Differences |
|---|---|---|---|
| 95 | 1.6 | .2 | 1.4 |
| 90 | 2.6 | .3 | 2.3 |
| 80 | 6.8 | .2 | 6.6 |
| 75 | 7.2 | .1 | 7.1 |
| 60 | 6.2 | .2 | 6.0 |
| 50 | 4.7 | .6 | 4.1 |
| 40 | 3.9 | 1.1 | 2.8 |
| 30 | 3.4 | 1.0 | 2.4 |
| 25 | 3.2 | .7 | 2.5 |
| 20 | 3.5 | .8 | 2.7 |
| 10 | 6.2 | 2.0 | 4.2 |
| 5 | 6.5 | 2.0 | 4.5 |

Finally, a curve, illustrated in Figure 15, was prepared by subtracting the lith dot fringe from the rapid access dot fringe at equivalent percent dot areas, illustrating graphically where differences in dot fringe are found on the halftone scale.

The results of employing the calibration curve support the data from the previous tests for fringe differences. Again, the rapid access first generation film exhibits a larger amount of dot fringe than the lith first generation film. In addition, Table 5 illustrates the dot fringe of the two samples throughout the halftone scale. As can be seen from the two curves in Figure 14, the dot fringe profiles of the two samples are similar with the exception of the three-quarter tone.

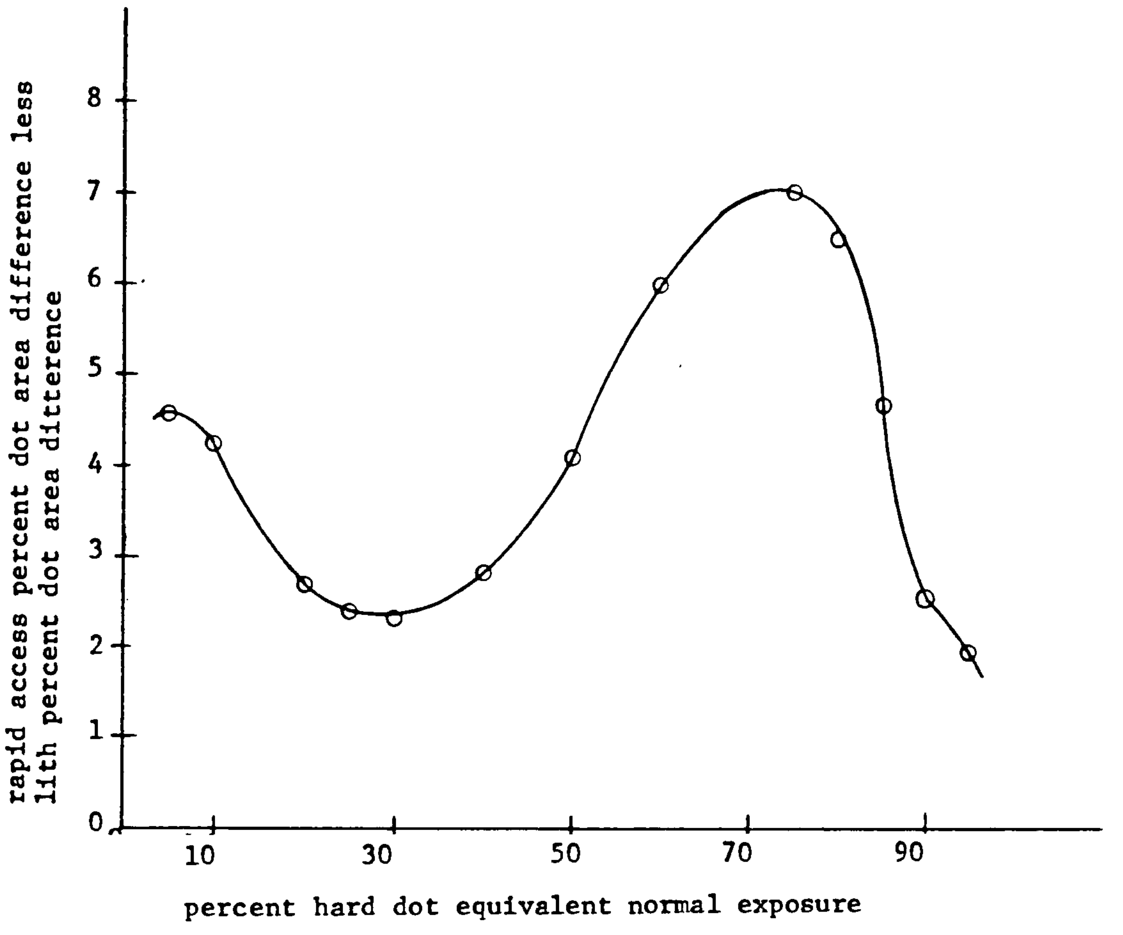


Fig.15. Corrected dot fringe profile of rapid access halftone film sample less lith halftone film sample

Sharp increases in the dot fringe at the ten percent shadow dot area may be the influence of low film Dmax for each of the two halftone film samples.

Comparing the test data derived from the microdensitometer traces to that of both the film contacting tests (uncorrected and corrected dot area differences) would seem to indicate that the fringe differences at the three-quarter tone area between the lith and rapid access halftone films could be attributed to the film contacting procedure, since the traces, unlike the contacting tests, do not indicate the largest amount of dot fringe at the three-quarter tone area.

Since the amount of dot chaining is effected by dot shape, and due to the differences in dot shape created by the two contact screens and the dot shape found on the UGRA hard dot scale, only after a micro study of the changes in dot geometry and dot chaining through contacting and its effect on dot area at the midtones, could conclusions be drawn.

--Section B--
Determining the Effective Printing Dot by
Meter Zeroing on the Ghost Dot

To test the effectiveness of the conventional method of dot fringe compensation on first generation halftones, three test samples were prepared by exposures derived from an exposure computer. Exposures were selected that yielded the greatest amount of manipulation of the tone scale, within the confines of the exposure computer program.

The three rapid access first generation halftone films were contacted simultaneously onto a single sheet of contact film.

Five contact percent hard dot areas (95, 75, 50, 25 and 5 percent) on each of the three samples were measured with the dot area meter zeroed on the film base. These same five areas were measured from the first generation sample films by zeroing the dot area meter on the identified ghost dot area. This ghost dot area was identified by the use of dark field illumination. The ghost dot having the smallest visible high density core was selected, representing the ghost dot area to which the dot area meter was zeroed (refer to Figure 16).

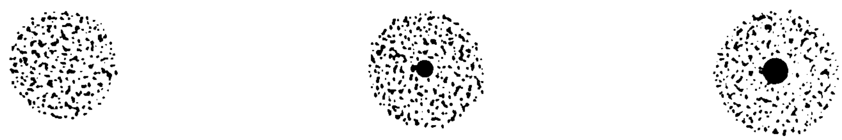

Fig.16A. No high density core

Fig.16B. Smallest high density core

Fig.16C. High density core too large

Fig.16. Visual criteria for the selection of the ghost dot

Fig.16B. Selected ghost dot

Presented in Table 6 is a summary of the equivalent percent dot areas of the first generation and second generation film contacts of the three original sample films. Included with the table is the computed exposure data for each of the three first generation halftone film samples. Refer to Appendix B1 for the complete ghost and contact dot area data for the halftone film samples.

TABLE 6

SUMMARY OF DIFFERENCES BETWEEN GHOST PERCENT DOT AREA OF FIRST GENERATION FILMS AND CONTACT SECOND GENERATION HARD DOT

| Equivalent Hard Dot Area | Main Exposure | | | Main & Flash Exposure | | | Main Flash and Bump Exposure | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ghost | Hard | Diff. | Ghost | Hard | Diff. | Ghost | Hard | Diff. |
| 95% | 99.0 | 94.9 | 4.1 | 98.1 | 93.0 | 5.1 | 98.9 | 94.9 | 4.1 |
| 75% | 85.8 | 72.6 | 13.2 | 87.9 | 76.2 | 11.0 | 95.7 | 71.7 | 24.0 |
| 50% | 69.2 | 50.9 | 18.3 | 67.9 | 49.9 | 18.0 | 91.3 | 55.3 | 36.0 |
| 25% | 31.8 | 26.1 | 5.7 | 28.0 | 24.2 | 3.8 | 49.2 | 24.7 | 24.5 |
| 5% | 1.1 | 5.5 | -4.4 | 2.9 | 7.0 | -4.1 | 9.8 | 11.5 | -1.7 |

Exposure Conditions

| | | | |
|---|---|---|---|
| Main Ex. | 700 | 479 | 36 |
| Flash Ex. | 0 | 153 | 223 |
| Bump Ex. | 0 | 0 | 18 |
| Bump % | 0 | 0 | 49% |
| Highlight Midtone Range | .59 | .70 | .36 |

The results of the comparison test between dot area measurements made by zeroing the dot area meter on the ghost dot area and its equivalent hard contact dot area for each of the five areas of the halftone scale reveal differences. These comparative differences range from a minimum of 4.1 percent dot area to a maximum of 36 percent. Differences in percent dot area of the three sample films are the most pronounced at the 50 percent dot area of the three sample films, and least pronounced at the 95 and 5 percent areas of the halftone scale. At the 95 percent dot area an "over-compensation" has occured, while at the 5 percent dot area an "under-compensation" exists. In terms of halftone exposure conditions, the data indicates the rapid access halftone produced with a main exposure only exhibits the least amount of difference in dot percent when compared to its second generation contact percent hard dot area. The flash, screened, non-image exposure has a slight effect of increasing this error, while the bump, no screen image exposure increases this error at the 50 percent dot area significantly (refer to Figure 17).

In conclusion, the method of dot fringe compensation by zeroing the dot area meter on the ghost dot area assumes that the density and area below the effective printing density surrounding the high density core of the ghost dot is equal to the same density and area of all first generation halftone dots regardless of size. The data presented does not indicate this relationship. The data also indicates a lack of linearity in dot fringe throughout the halftone scale. As a result of this lack of linearity, when using a three aim point control system for evaluating first generation halftone films, a degree of accuracy

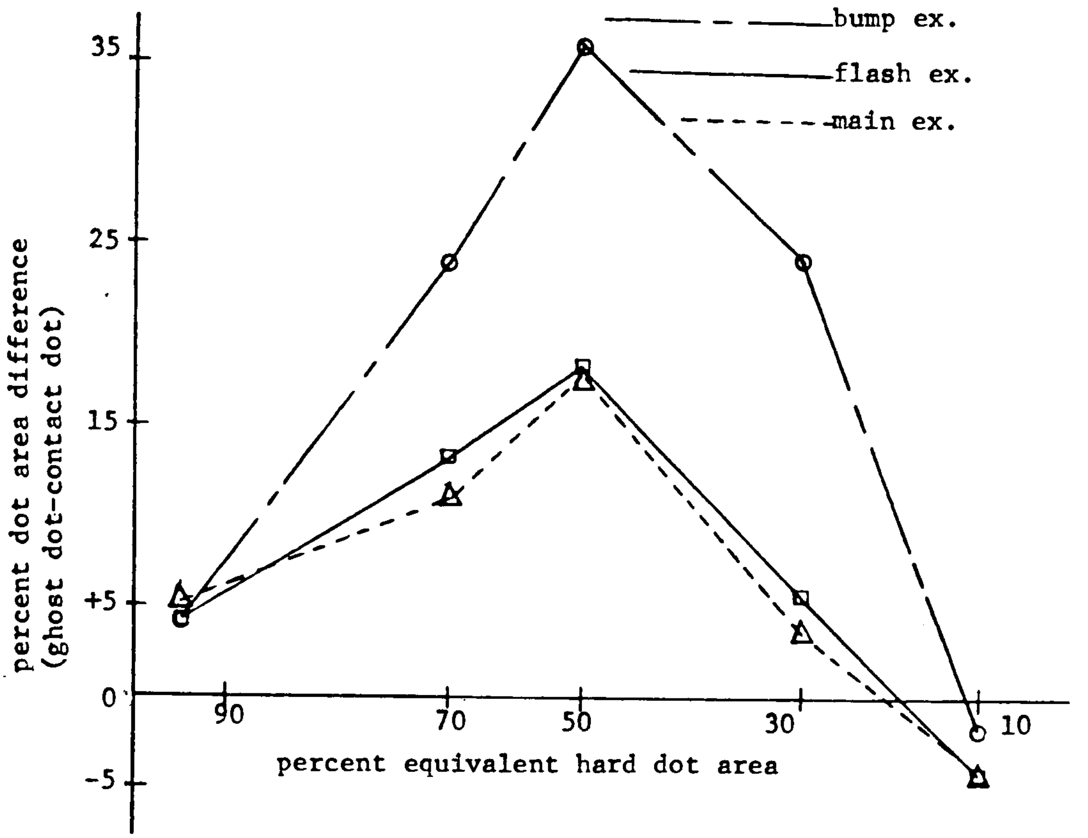


Fig.17. Percent dot area difference between ghost dot and contact dot at equivalent percent hard dot areas

in measuring the effective printing dot could only be established at one control point at the expense of the remaining two control points of the system.

As this compensation method is evaluated according to the data presented, it is evident that the selection of the ghost dot is critical; secondly, there is a poor correlation between the ghost percent dot area and its equivalent second generation contact dot area throughout the halftone scale.

## --Section C--
## Proposed Method of Fringe Compensation

The objective of the proposed fringe compensation method is to design a more accurate means for determining the effective printing dot when measuring percent dot area of rapid access first generation halftone films. The method should be easy to use and adaptable to existing instrumentation.

Three basic steps were followed in the design of the method. The first step was to identify dot fringe variability caused by various halftone exposure conditions. The second step was to derive the necessary calibration/correction data. The final step was to test the accuracy of the method.

### Dot Fringe Variability Resulting from Exposure

A halftone exposure computer was used to determine three basic halftone exposure conditions. The first test film was given a main exposure only, the second test film a main exposure plus a maximum flash exposure, and the third test film a main, flash, and maximum bump exposure. The three test films were simultaneously contacted onto a sheet of contact film. Presented in Appendix C1 are the measured dot percent areas of the first generation soft dot halftone films and their respective second generation hard dot contact films. All percent dot area readings were taken by zeroing the dot area meter on the film base.

The data from Appendix C1 is presented graphically in Appendix C2-A through C2-C, illustrating the percent dot area produced by the

the three exposure conditions for the first generation halftone films and their second generation contact films. Table 7 was prepared by extracting from the curves in Appendix C2-A through C2-C percent dot area differences between the first generation halftone films and their respective contact films at equivalent percent dot areas.

TABLE 7

PERCENT DOT AREA DIFFERENCES OF FIRST GENERATION HALFTONE FILMS AND THEIR RESPECTIVE SECOND GENERATION CONTACT FILMS AT EQUIVALENT PERCENT DOT AREAS FOR THREE TEST EXPOSURE CONDITIONS

| Equivalent | Main Exposure | | | Main & Flash Exposure | | | Main, Flash & Bump Exposure | | |
|---|---|---|---|---|---|---|---|---|---|
| % Dot Area | Soft | Hard | Diff. | Soft | Hard | Diff. | Soft | Hard | Diff. |
| 90 | 97.0 | 90.0 | 7.0 | 97.0 | 90.0 | 7.0 | 98.5 | 90.0 | 8.5 |
| 70 | 87.5 | 70.0 | 17.5 | 97.0 | 70.0 | 17.0 | 95.5 | 70.0 | 25.5 |
| 50 | 74.0 | 50.0 | 24.0 | 76.0 | 50.0 | 26.0 | 91.5 | 50.0 | 41.5 |
| 30 | 51.0 | 30.0 | 21.0 | 51.5 | 30.0 | 21.5 | 69.5 | 30.0 | 39.5 |
| 10 | 26.0 | 10.0 | 16.0 | 25.0 | 10.0 | 15.0 | 16.5 | 11.5 | 5.0 |

Percent dot area differences for the three exposure conditions are presented in Figure 18.

The results illustrate that differences in percent dot area of the first generation halftone film and its film contact produced by a main exposure only and a main and maximum flash exposure are negligible. The differences produced by the main, flash and maximum bump exposure are significantly greater than those of the first two exposure conditions. Therefore, percent dot area correction factors are applicable to halftone films produced by main, or main and flash exposures. Different dot area correction factors would be necessary when measuring percent dot area on halftone films produced with bump exposures.

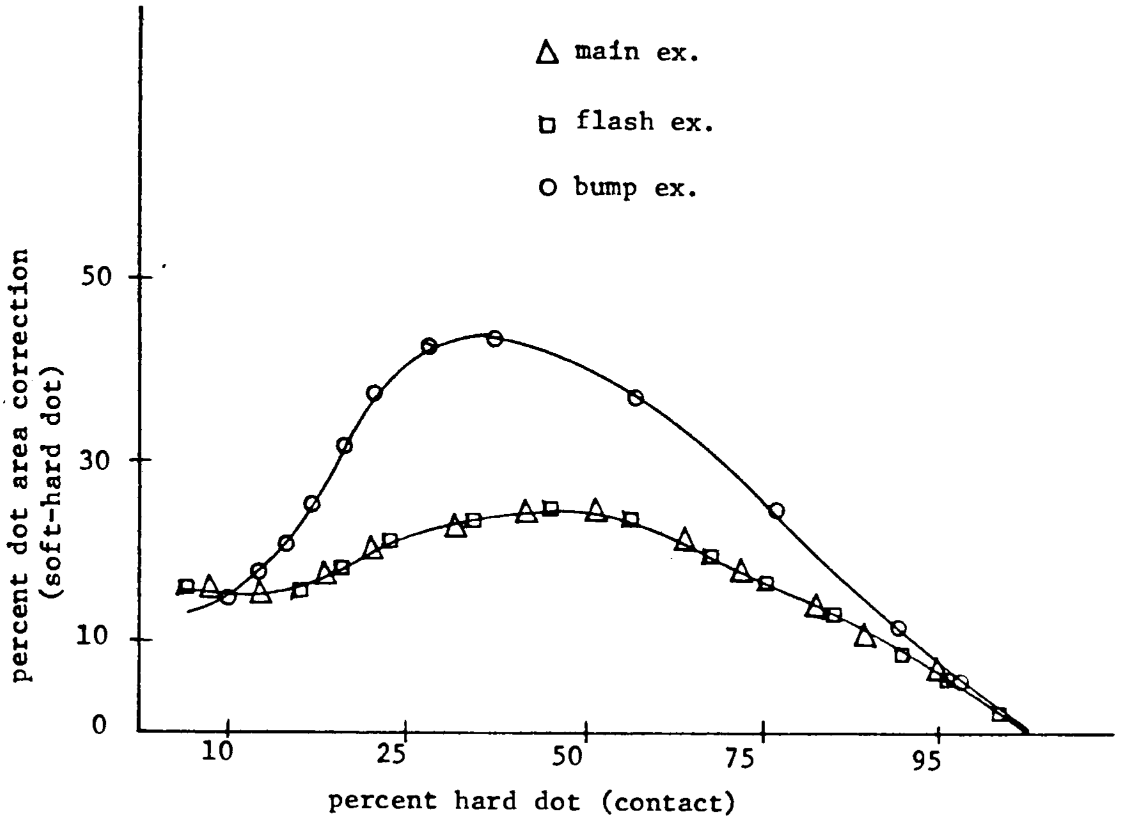


Fig. 18. Differences in percent dot area of first generation soft dot films and second generation hard dot films produced by three text exposure conditions

## Collection of the Calibration Data

Two sources of calibration data for percent dot area correction are required. The first source of data is percent dot area differences (percent dot area correction) required for main and main plus flash exposure conditions. A percent dot area correction curve is prepared by plotting the percent hard dot of the contact film versus the first generation halftone film percent dot area less the contact hard dot area of an equivalent percent dot area. Presented in Figure 19 is this correction curve. Data used to plot the correction curve is located in Appendix C3.

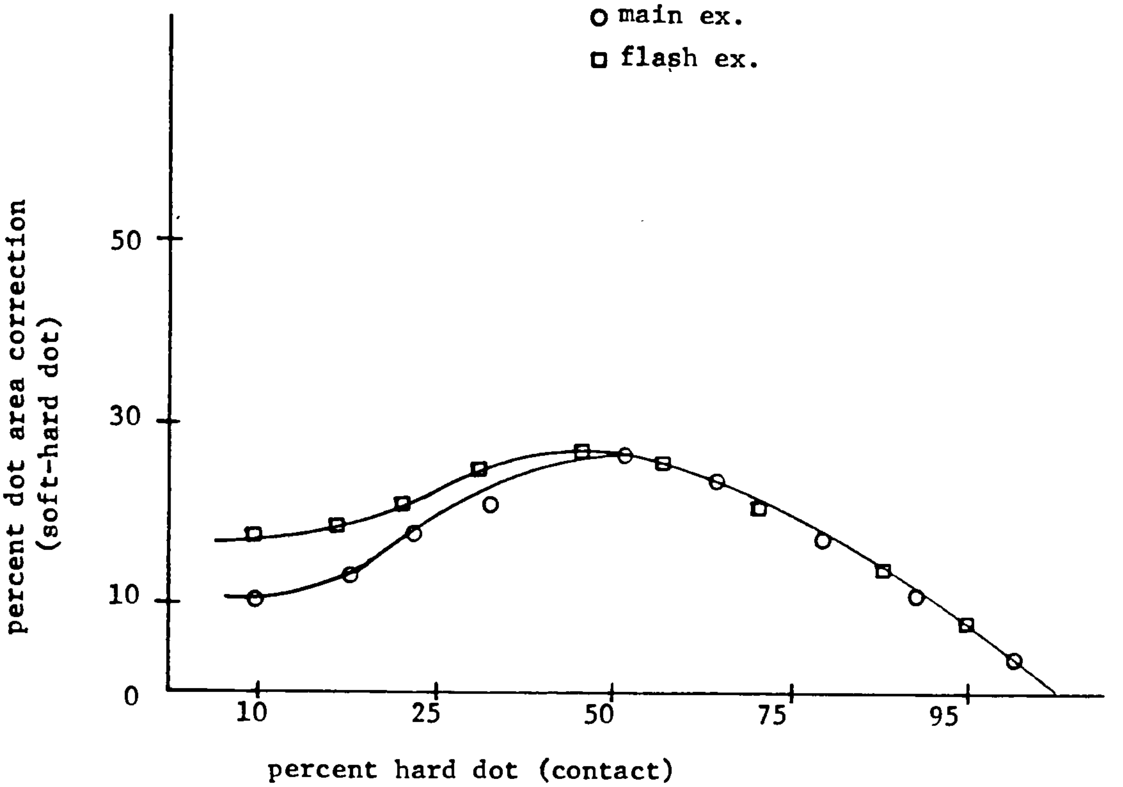


Fig. 19. Percent dot area correction for halftone films produced with main and flash exposures

The second source of calibration data is found by determining the percent dot area correction required for halftone films produced with varying amounts of bump exposure. For these particular test conditions, the exposure computer computed a maximum bump exposure of 34 percent of the main exposure. A series of three bump exposures were selected. Test films were prepared having bump exposures of 34, 20 and 10 percent. Dot area correction was calculated and plotted in Figure 20. Data used to plot the correction curve is located in Appendix C4.

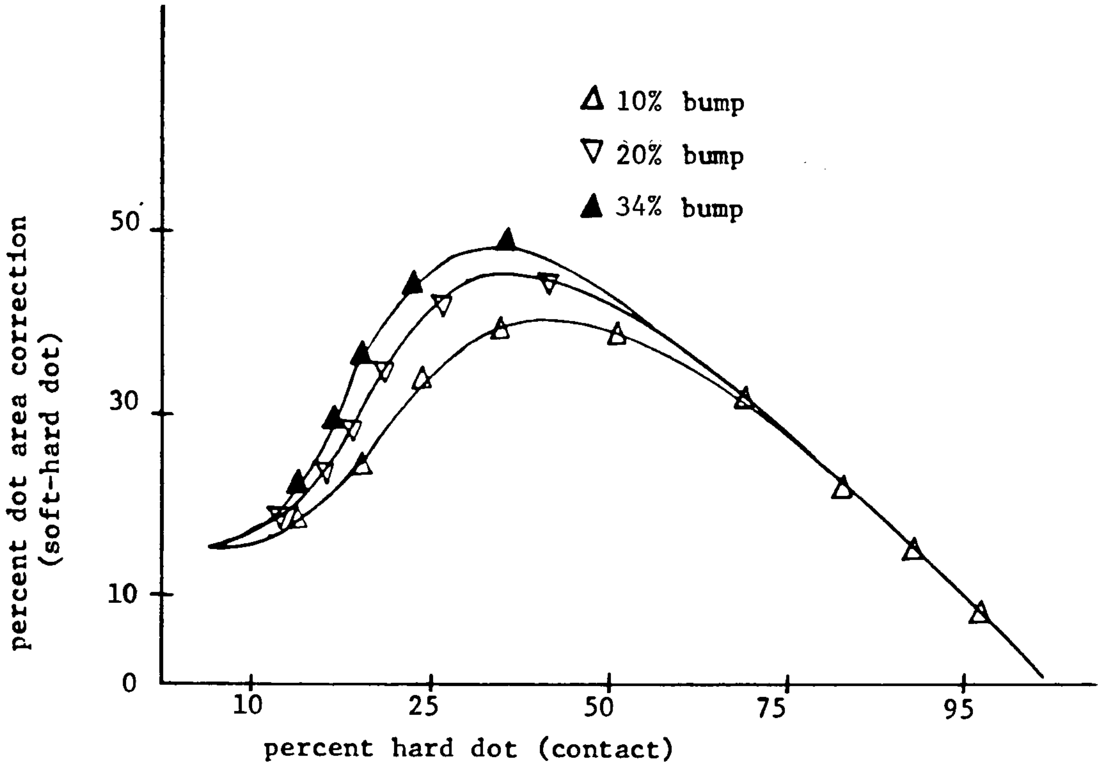


Fig.20. Percent dot area correction for halftone films produced with bump exposures

The percent dot area correction curves for all three of the basic exposure conditions were combined and presented in Figure 21. Percent dot area aim points of 10, 50 and 80 percent were selected. Percent dot area correction values were subtracted from the correction curves for each of the four exposure conditions (refer to Table 8).

A percent dot area reference table was constructed and the data from Table 8 was entered into the correction table (refer to Table 9).

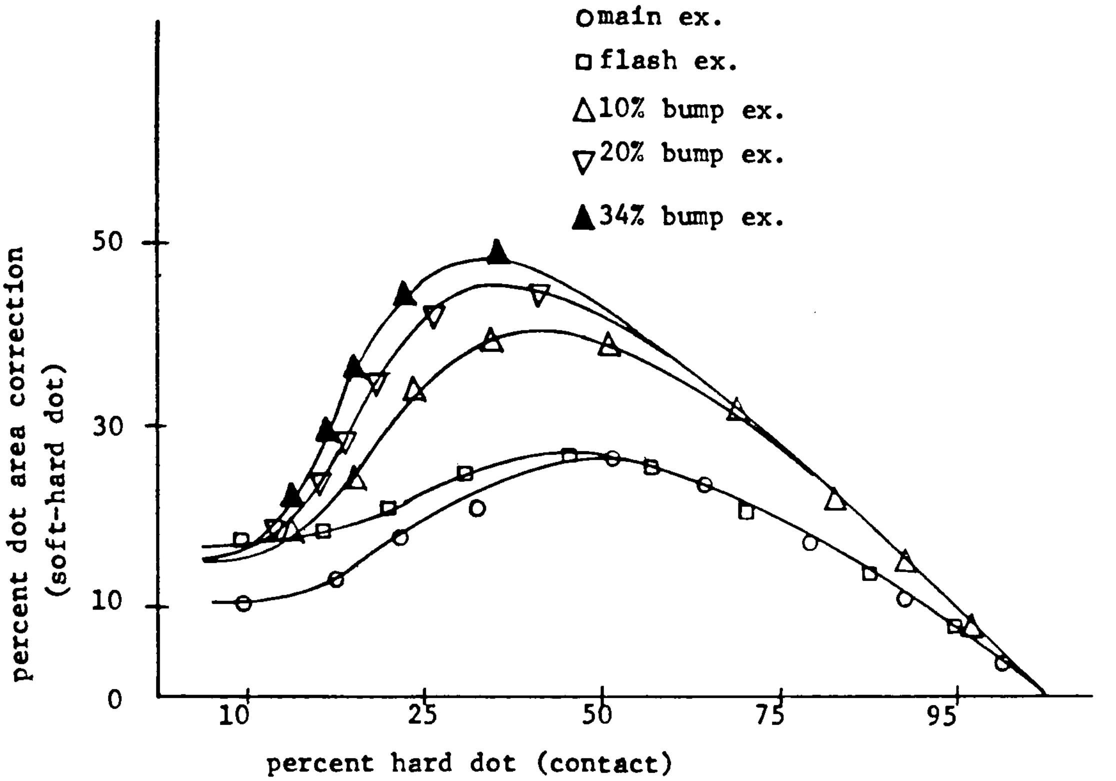


Fig.21. Percent dot area correction for halftone films produced with main, flash and bump exposures

TABLE 8

PERCENT DOT AREA CORRECTION FACTORS FOR SELECTED PERCENT DOT AREA AIM POINTS

| Halftone Percent Dot Area Measured Selected Aim Points For Halftone Negatives | PERCENT DOT AREA CORRECTION VALUES FOR VARYING HALFTONE EXPOSURE CONDITIONS | | | |
|---|---|---|---|---|
| | Halftone Exposures Requiring Main and Flash Exposures | Halftone Exposures Requiring Bump Exposures | | |
| | | Selected Bump Exposures Expressed as a Percentage of the Main Exposure | | |
| | Main or Main and Flash Exposures | 10% | 20% | 30% |
| 80% | 14% | 19% | 19% | 19% |
| 50% | 27% | 39% | 42.5% | 43% |
| 10% | 14% | 10.5% | 11.5% | 11.5% |

TABLE 9

PERCENT DOT AREA REFERENCE TABLE - CORRECTED DOT AREA VALUES FOR FIRST GENERATION HALFTONE FILMS

| Percent Dot Area Aim Points | Required Dot Area Meter Readings For Various Halftone Exposure Conditions | | | |
|---|---|---|---|---|
| | Main and Flash Exposures | Bump Exposures 10% | 20% | 30% |
| 80% | 94% | 99% | 99% | 99% |
| 50% | 77% | 89% | 92.5% | 93% |
| 10% | 24% | 20.5% | 21.5% | 21.5% |

## Testing of the Fringe Compensation Method

In order to test the fringe compensation method and the accuracy of the correction values of the dot area correction table, a series of six halftone test exposure films were prepared. Exposures for the six test films were derived from the exposure computer. A range of exposure combinations were selected based upon manipulation of the highlight to midtone range. Presented in Appendix C5 are the dot area readings taken from the six first generation test films and their respective second generation contact hard dot films. Also included are the exposure conditions derived from the exposure computer.

## Use of the Dot Area Reference Table

The dot area reference table (refer to Table 9) is used when evaluating percent dot area of first generation halftone films to determine the effective percent dot area. The values found in the boxed-in area of the table represent what the percent dot area of each of the three highlight, midtone and shadow aim points should measure from the dot area meter after zeroing the meter on the film base only. Compensation values for the two basic exposure conditions are incorporated into the table.*

## Results of Employing the Dot Area Reference Table

Percent dot areas of the six first generation halftone films were measured with the dot area meter. Differences in dot area after use of the dot area reference table and dot area differences of the first generation and second generation films are presented in Table 10.

TABLE 10

PERCENT DOT AREA DIFFERENCES OF DOT AREA CORRECTION FACTORS AND DOT AREA DIFFERENCES OF FIRST GENERATION SOFT DOT HALFTONES LESS SECOND GENERATION CONTACT FILMS

| Percent Dot Area Aim Point | Ex.#1 | Ex.#2 | Ex.#3 | Ex.#4 | Ex.#5 | Ex.#6 | Av. Diff. |
|---|---|---|---|---|---|---|---|
| 80% | -+.1 | -.3 | -.7 | -.1 | +.6 | -.7 | .4 |
| 50% | +2.5 | +1.8 | +.7 | -5.0 | +1.9 | -4.0 | 2.7 |
| 10% | +4.5 | +5.5 | +5.1 | +5.8 | +.7 | +1.4 | 3.8 |

Table 10 illustrates that when first generation rapid access halftone films, exposed under a wide range of exposure conditions, are measured with the dot area meter to determine the effective printing percent dot area by referring to the percent dot area reference table, percent dot area error is minor. Average dot area error is approximately one-half percent for the highlight area, three percent at the midtone and five percent at the shadow area.

Figures 22A and 22B illustrate the percent dot area error after applying the percent dot area reference table.

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*For step by step calibration procedure, refer to Appendix C6.

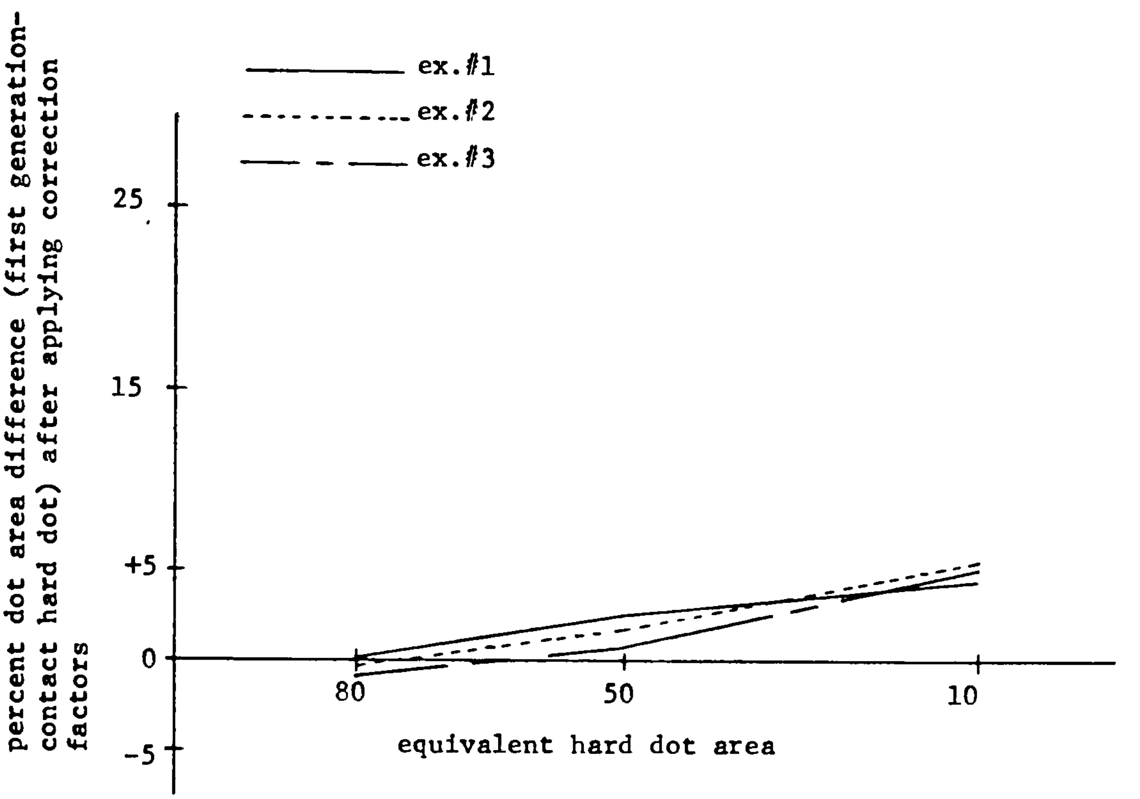


Fig.22A. Percent dot area differences for test exposures #1 through #3

Figures 22A and 22B indicate measurement error is reduced in determining the effective printing dot compared to using the method of zeroing the dot area meter on the ghost dot (refer to Figure 17).

The results of employing the calibration/correction method indicate the method has merit in determining the effective percent dot area of first generation rapid access halftone films. Due to a small test film sample size and no testing of the rapid access process stability, definitive statements cannot be made as to the repeatability and reliability of the method. In addition, no correlation study was conducted between the simulated method of determining the effective printing dot as it would appear on an ink and paper

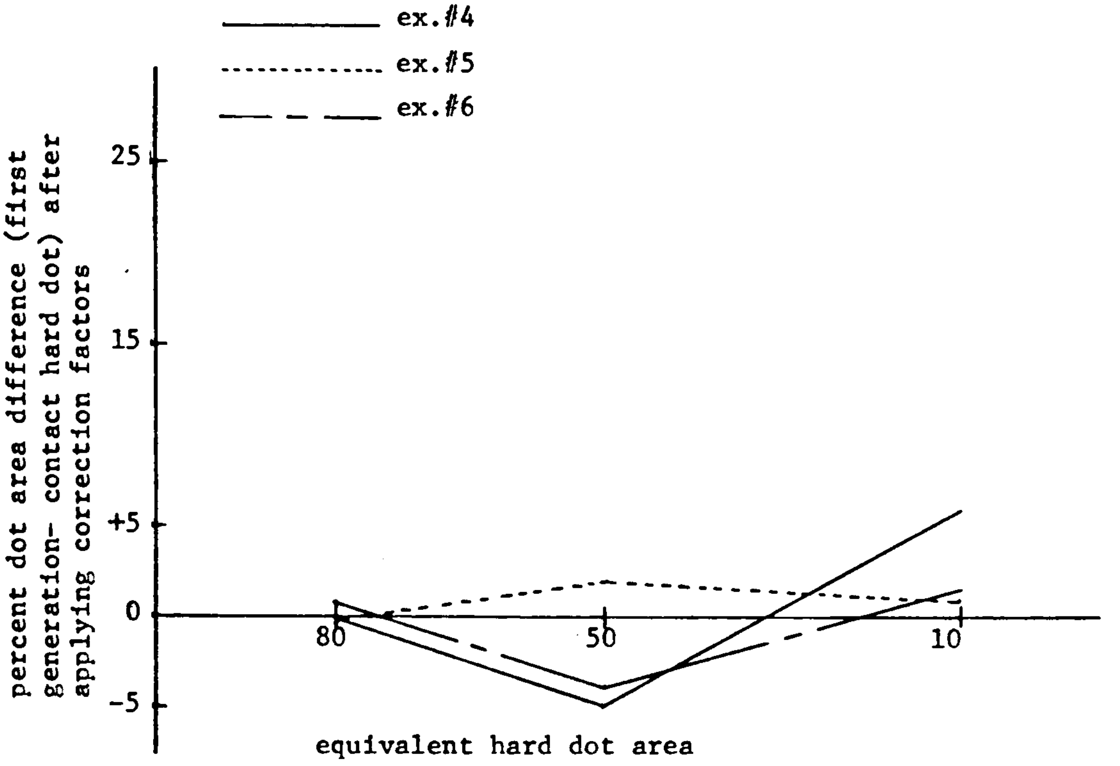


Fig.22B. Percent dot area differences for test exposures #4 through #6

Fig.22. Percent dot area differences between corrected percent dot area measurements and contact percent hard dot at equivalent percent hard dot areas

reproduction. In actual practice, dot area correction factors would be based upon data derived from printing press reproductions, thus including the effects of platemaking and press reproduction on the effective percent dot area of the halftone films.

# CHAPTER V

## Summary and Conclusions

### Comparison of Dot Fringe Characteristics of Rapid Access and Conventional Lith Halftones

Visual differences in dot fringe as illustrated by microphotographs of the lith and rapid access samples illuminated by oblique illumination indicated the rapid access halftone film sample had a larger low density area surrounding the higher density center of the dot throughout the halftone scale than did the conventional lith halftone film sample. In addition, the effect of oblique illumination on this fringe area was most pronounced at the 50 percent area of the halftone scale.

Microphotographs of the two different film samples illuminated by oblique and bright field illumination illustrated a distinct difference in dot geometry of the two halftone film samples produced by contact screens each having an elliptical dot shape. The rapid access first generation halftone dot is characterized by having sharp pointed corners in comparison to the lith first generation halftone dot. Further, the sharpness of the dot corners contributed to the loss of dot area when contacted to film.

Measurement of the halftone dot edge gradient of the two halftone film samples produced a sharper halftone dot density edge gradient throughout the halftone scale. Expressed as a ratio, the rapid access film had approximately a two-fold increase in dot width at the specified density boundary levels than the lith film sample.

Further investigation of the differences in dot fringe of the two film samples was conducted by film contacting the samples at selected over- and under-exposures to contact film. These exposures were based upon an exposure necessary to yield a typical .90 critical density relating to the plate sensitivity guide number. It was assumed that the hardest dot from the first generation halftone films would yield the smallest difference in percent dot area when the percent dot area of the over-exposed contact film was subtracted from the percent dot area of the under-exposed contact film.

Again, this test indicates the rapid access sample has a more highly fringed halftone dot. Comparative dot area differences of the two films produced by the over- and under-exposure conditions produced a range of dot area differences of .9 percent to 8.1 percent. The test indicates the largest dot area difference produced by the two contact exposures to be found at the 75 percent area of the halftone scale.

To more accurately quantify this difference in dot area through contacting to film, the contacting system was, in effect, calibrated to remove percent dot area increases due to dot gain caused by light spread as it exits the first generation film and strikes the contact film, and also changes as in the amount of dot chaining at the midtones (midtone jump). As a result of the calibration procedure, dot area differences due to film contacting of the sample films were approximately 2 percent less than the "uncalibrated" test, but the relationship of dot area differences throughout the halftone scale was comparable. No qualified explanation was given as to why there are significantly greater differences in percent dot area at the 75 percent area of the halftone scale.

## Determining the Effective Printing Dot by Meter Zeroing on the Ghost Dot

Measuring the effective dot area of first generation rapid access halftone films by first compensating for dot fringe through zero referencing the dot area meter on the identified ghost dot was found to produce error throughout the halftone scale when the measured areas were compared with their second generation hard contact dot areas.

Three test films were prepared using various halftone exposure combinations. The first two test films prepared with a main exposure and a main and flash exposure produced approximately the same difference in dot area when compared to their second generation contact film. On the main exposure only test film, the highlight area produced a 4.1 percent error, the midtone an 18.3 percent error, and the shadow area a 4.4 percent error. The third test film prepared with a 49 percent bump exposure produced the same amount of error in the highlight area, a slight (2 percent) reduction in the shadow area, and at the midtone produced a significant error of 36 percent.

The results of the fringe compensation test illustrate that dot fringe does not occur uniformly throughout the halftone scale. It is evident that when evaluating two or more areas of the halftone scale, the selection of the ghost dot is critical and that there is a poor correlation between the ghost percent dot area and its equivalent second generation contact dot area throughout the halftone scale.

## Proposed Method of Fringe Compensation

An attempt was made to account for the errors produced by the traditional method of fringe compensation described above. Compensation factors were determined for the two primary sources of dot area measurement error. A more fully refined compensation method was designed to account for the dot fringe variability produced by bump exposures and also by extracting correction factors for three areas of the halftone scale (highlight, midtone and shadow) rather than one area (shadow). Six test films were prepared and evaluated by applying the correction factors. Again, the percent dot error was found by comparing the compensated measured dot area to its second generation hard contact dot area. Average differences of the amount of error of the six films were lower than the ghost dot compensation method. The average error in the highlight area was .4 percent, in the midtone 2.7 percent, and in the shadow area 3.8 percent. Due to the small sample size, the results are not conclusive, but do show a marked difference in the amount of dot area error. In addition, the compensation method does not solve the fundamental problem of dot area measurement of first generation films. It does, however, reduce much of the error found in the traditional method of fringe compensation. What is needed is an instrument that scans several dots and measures the average dot percent area at a given density corresponding to the first step of the sensitivity guide on the printed sheet.

# CHAPTER VI

## Recommendations for Further Study

There are several problems associated with the rapid access halftone technique that were either briefly mentioned or were beyond the scope of this investigation. Since this study compared only one rapid access contact screen to one conventional lith screen, no definitive statements can be made as to the effect of the design of rapid access screens on dot sharpness. Even though the microdensitometer trace of the rapid access contact screen did not indicate the highly stylized density profile reported in the literature, this author can offer no statements in regards to the effect of screen design on halftone dot sharpness. Of interest would be a study conducted of several rapid access screens and an evaluation of the dots produced by these various screens.

Also of interest would be a study of such processing variables as developer temperature and development speed on the sharpness of the halftone dot. In addition, there arises the question of whether the rapid access process produces a significantly lower film Dmax and higher film fog than conventional lith halftone photography, and if so, whether this is a significant problem with the process.

Finally, of benefit to both the lith and rapid access halftone techniques, would be the design of a dot area meter which more accurately measures the dot area of first generation halftone films than what is currently in use in the industry.

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# APPENDIX A

## DOT FRINGE CHARACTERISTICS OF RAPID ACCESS AND CONVENTIONAL LITH HALFTONES

# APPENDIX A1

## HALFTONE SAMPLE FILM PREPATATION

### Lith Sample Halftone Film

Film: Kodilith Ortho Type 111 #2556

Contact Screen: Respi Gray Negative Eliptical 133 Line

Exposure Condition: Main Exposure Only

Film Processor: LogE LD-24-AQ

Processor Chemistry:

Developer- 3M AQD Lith Developer
Replenishment- 3M AQR Lith Replenisher Part/BR
Fixer- DuPont Cronalith Fixer
Developer Rate- 110 Seconds
Developer Temperature- 81°F

### Rapid Access Sample Halftone Film

Film: Kodak Kodaline Reproduction #2586

Contact Screen: Caprock Gray Negative Eliptical RA 133 Line

Exposure Condition: Main Exposure Only

Film Processor: Pako 24 SQ

Processor Chemistry:

Developer- Kodak Super Rapid Access Developer
Replenishment- Kodak Super Rapid Access Developer
Fixer- Kodak Rapid Fixer
Development Rate- 25 inches/minute
Developer Temperature- 100°F

# APPENDIX A2

## FILM CONTACTING METHOD

Film: Kodalite Contact Film #2573

Contact Orientation: Emulsion to Emulsion in Vacuum Frame

Exposure Condition: Integrated Exposure through 18A Filter

Film Processor: Paco 24 SQ

Processor Chemistry:
- Developer- Kodak Super Rapid Access Developer
- Replenishment- Kodak Super Rapid Access Developer
- Fixer- Kodak Rapid Fixer
- Development Rate- 25 inches/minute
- Developer Temperature- 100°F

# APPENDIX A3

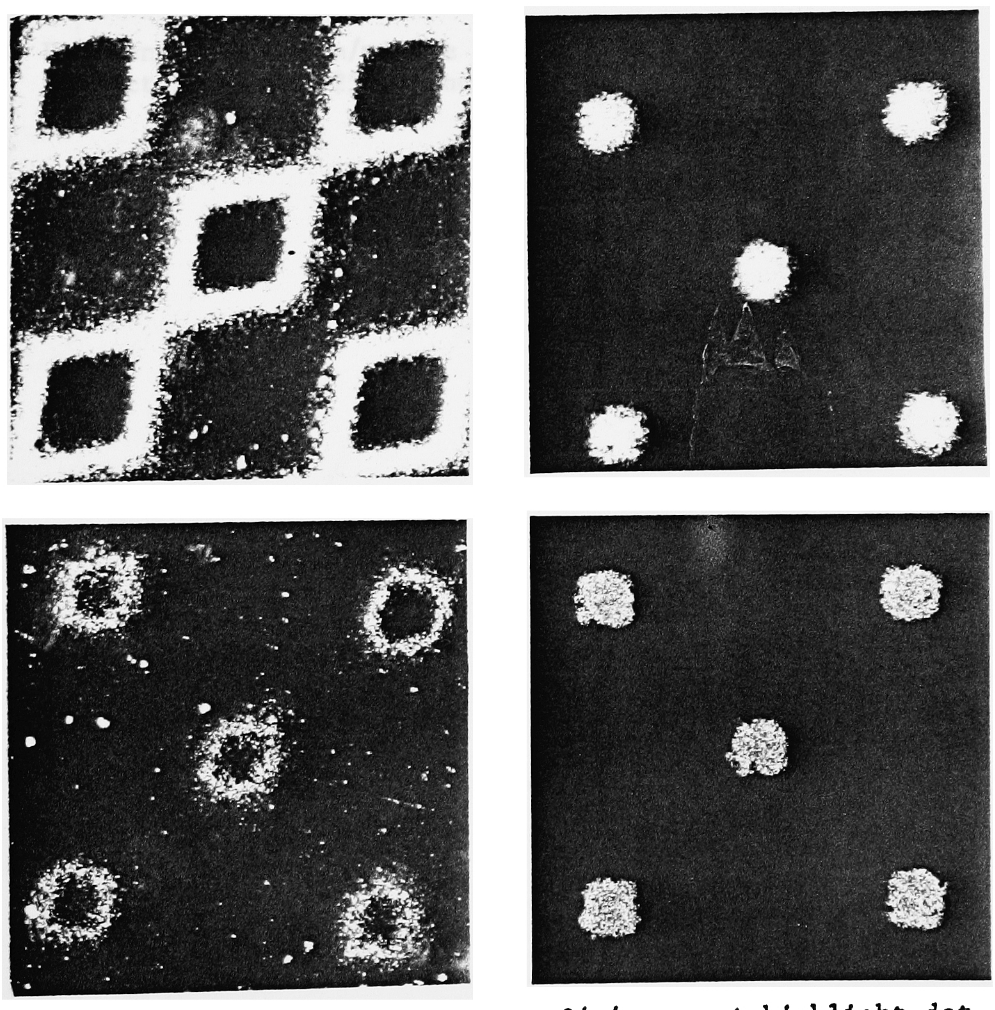
MICROPHOTOGRAPHS OF HIGHLIGHT AND SHADOW DOTS OF RAPID ACCESS AND LITH HALFTONES WITH OBLIQUE ILLUMINATION

16.7 percent shadow dot

95.4 percent highlight dot

rapid access

lith



4.5 percent shadow dot

94.4 percent highlight dot

# APPENDIX A4

## MICRODENSITOMETER SET-UP AND OPERATION

Model: GAF Automatic Recording Microdensitometer Model 4

Optics: Eyepiece- 12.5X
Objective- 20X

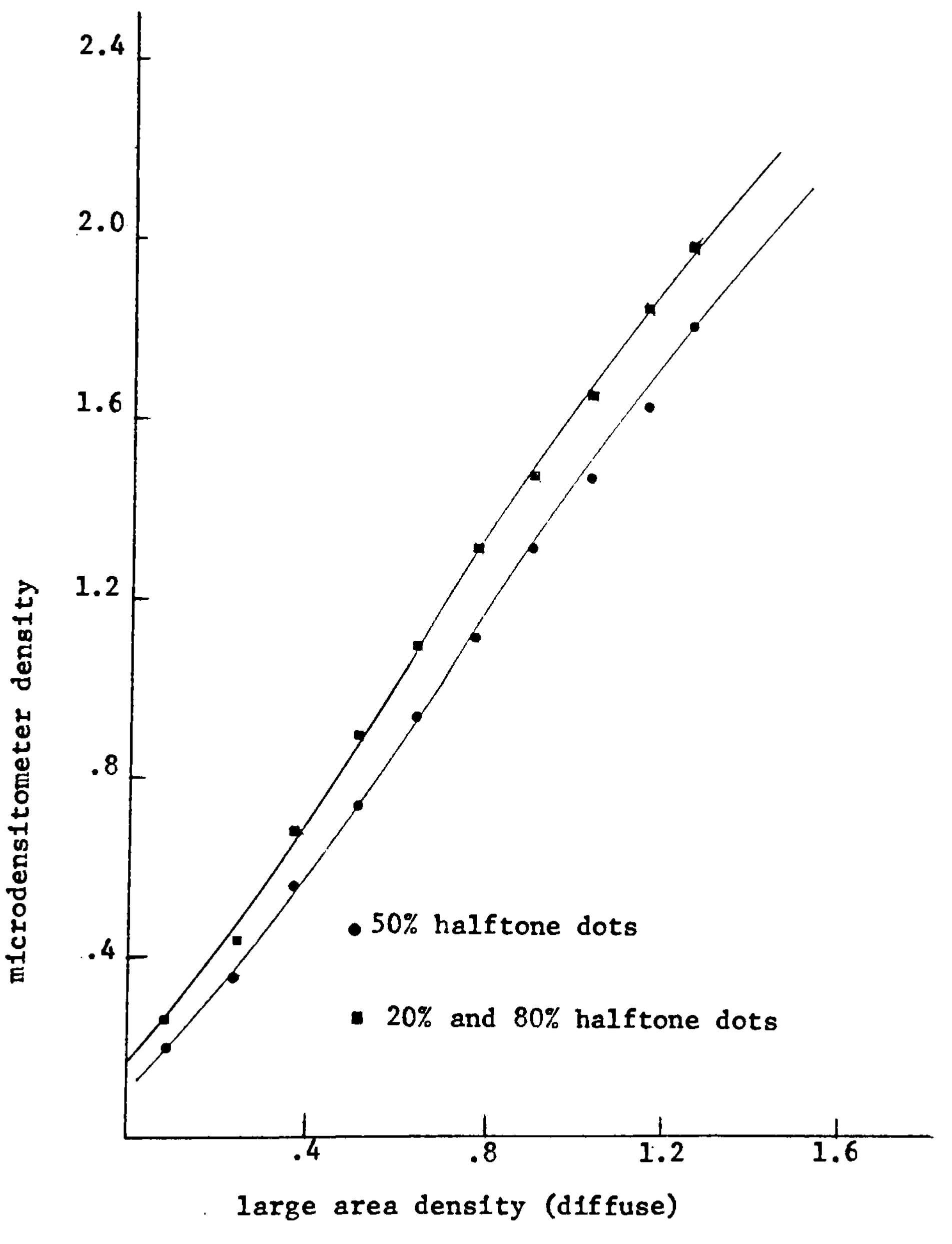
Magnification: 280X

Effective Aperature: 4.5μm X 4.5μm

Stage Speed: Halftone Dots- .1mm/minute
Contact Screens- .25mm/minute

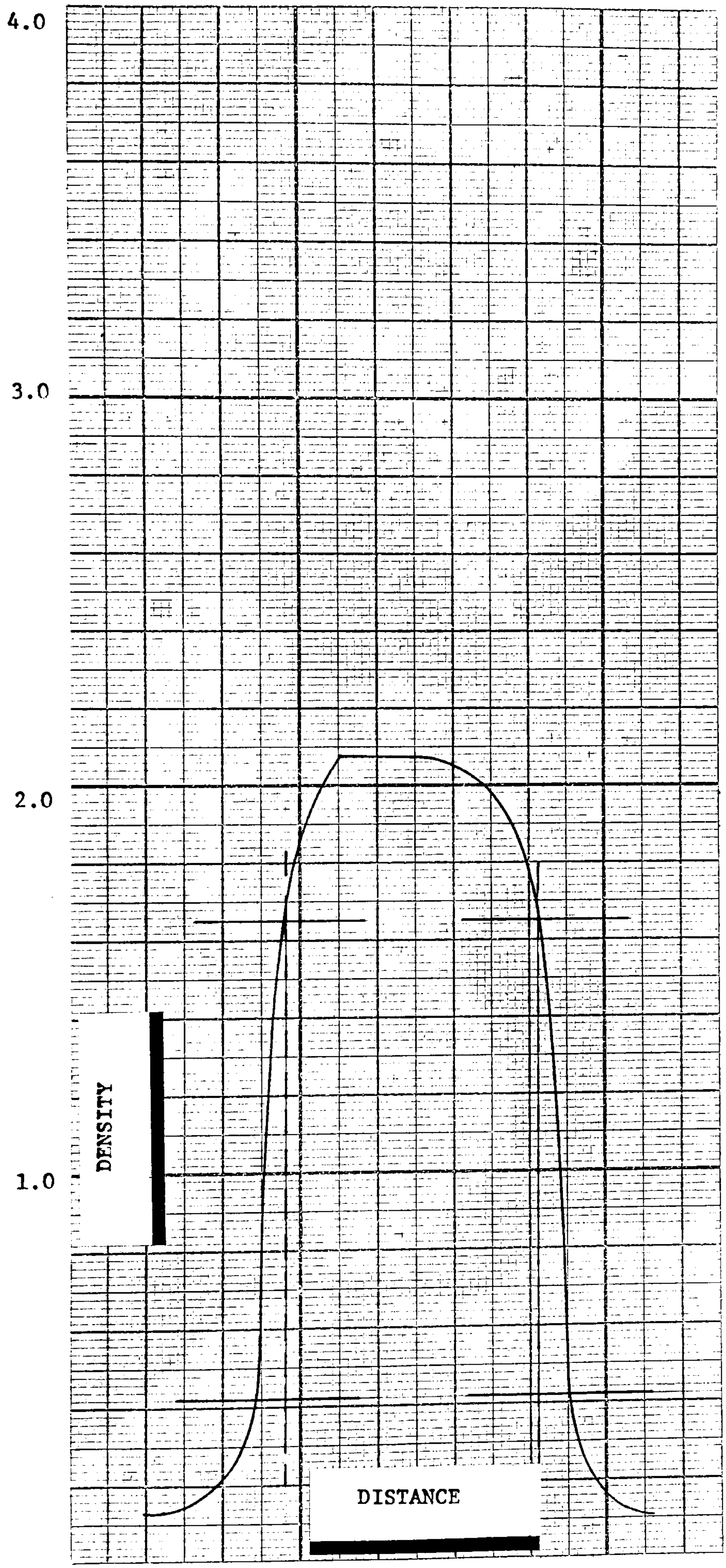
APPENDIX A5

MICRODENSITOMETER CALIBRATION CURVE

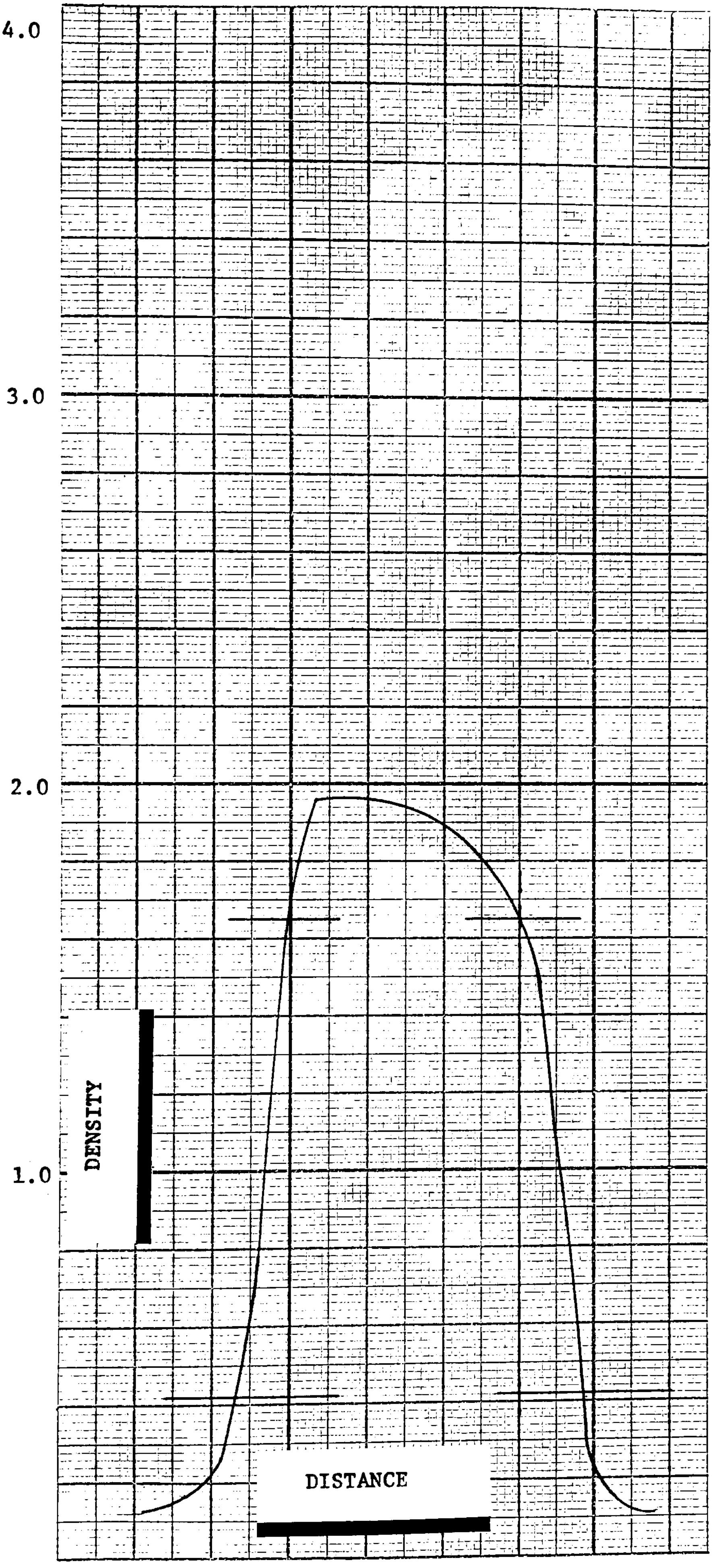


# APPENDIX A6-A

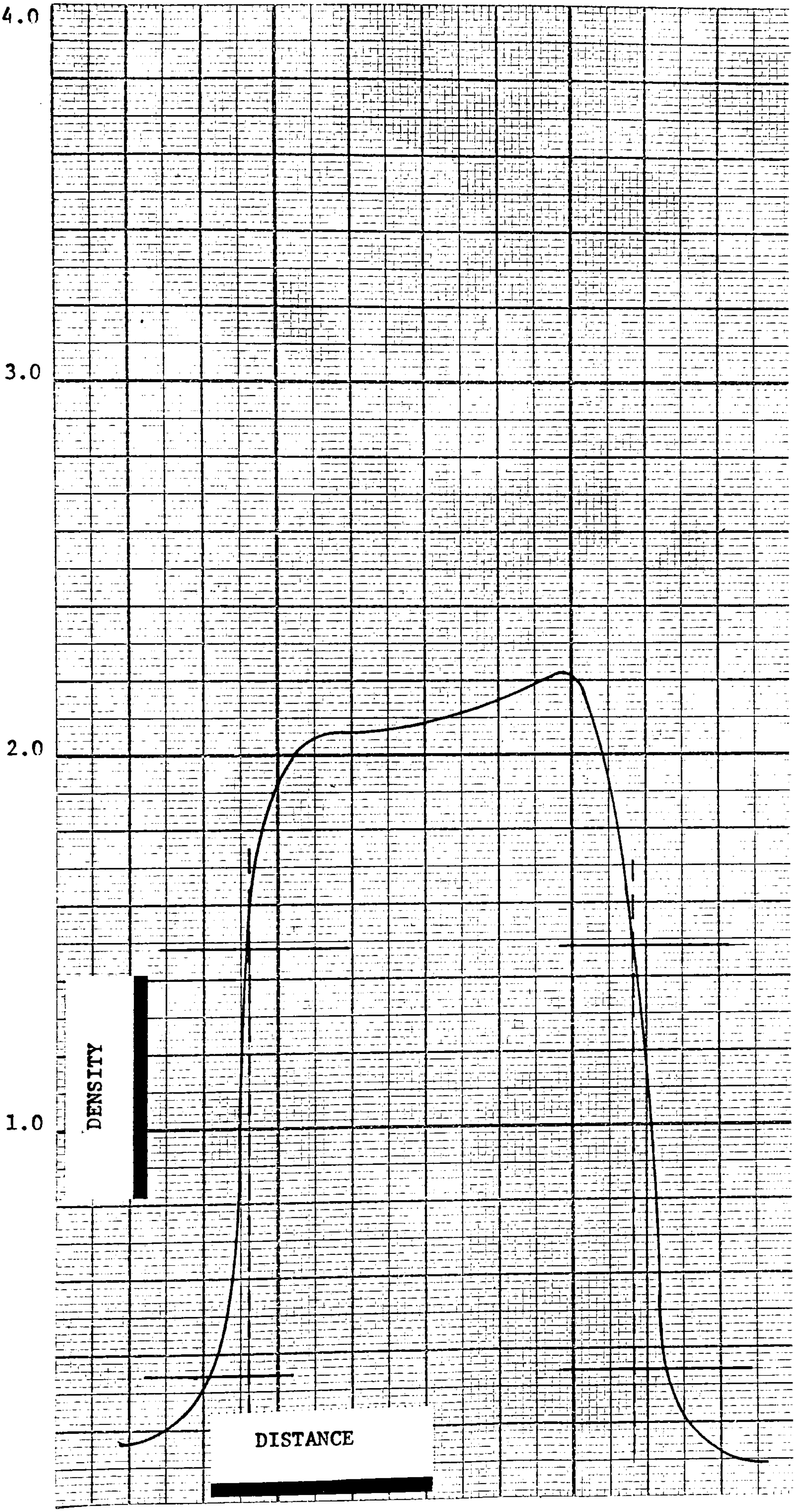
MICRODENSITOMETER COMPOSITE TRACES OF LITH AND RAPID ACCESS HALFTONE DOTS



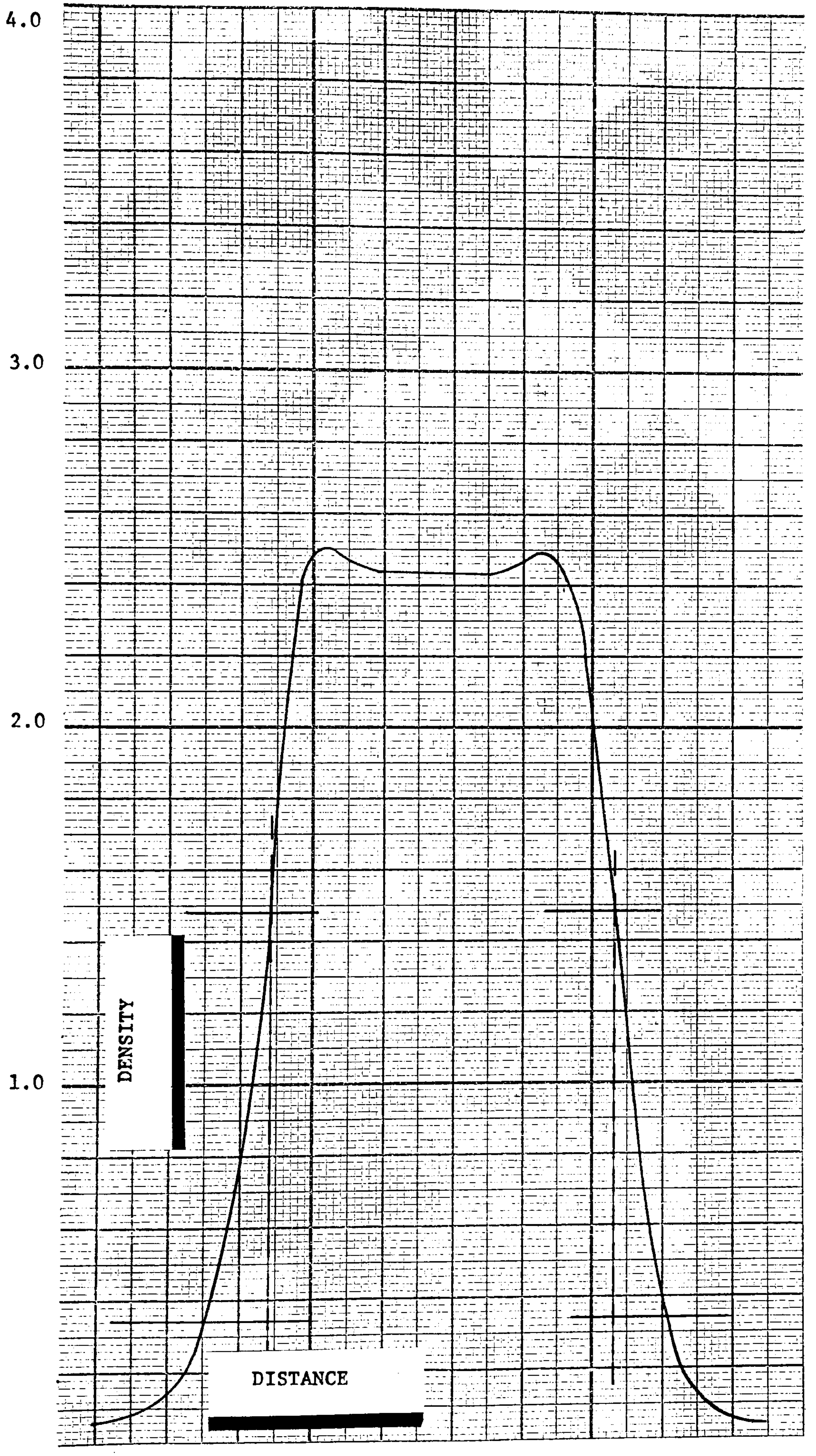

Lith 21.7 Percent Composite Halftone Dot



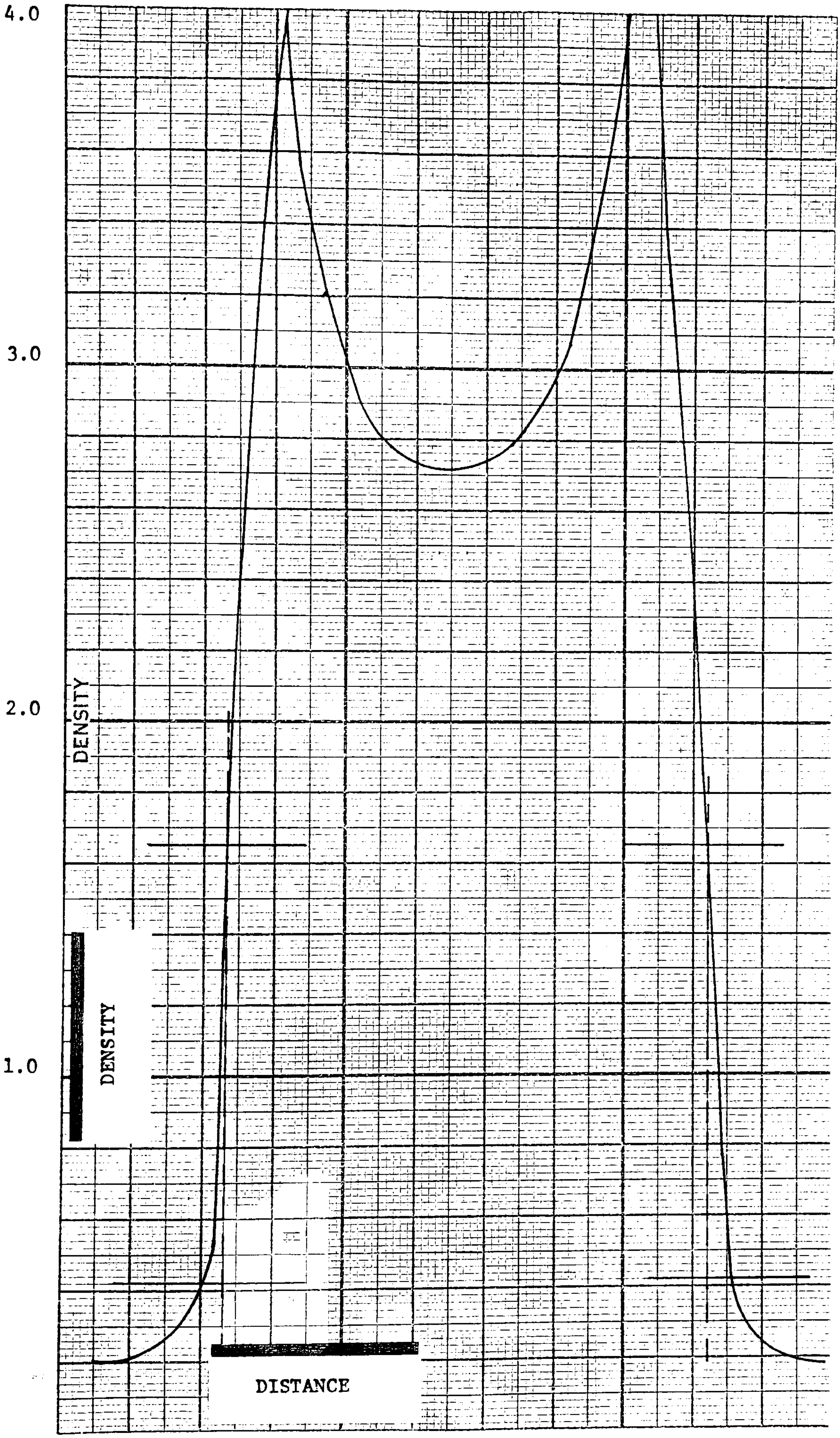

Rapid Access 24.3 Percent Composite Halftone Dot



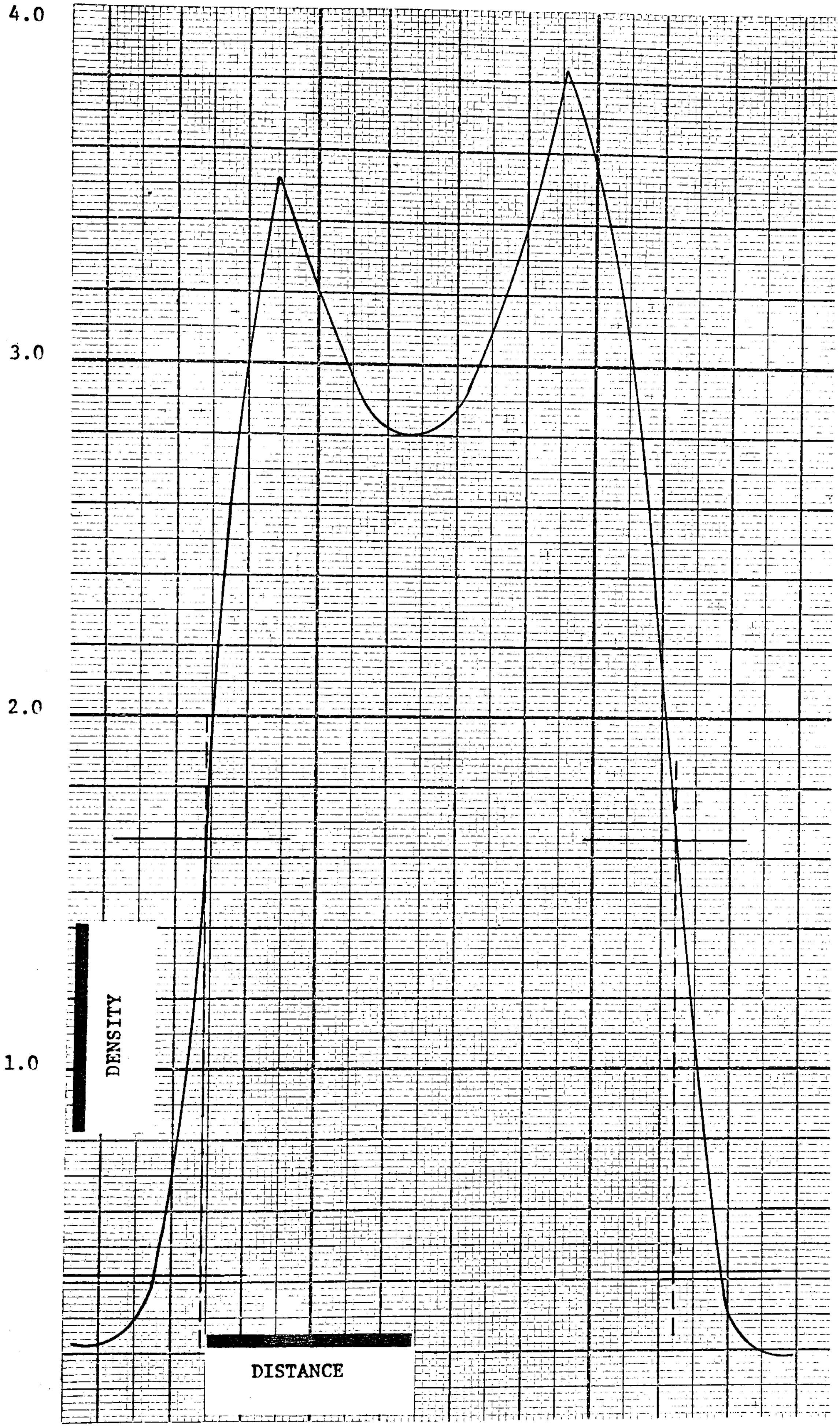

Lith 50.6 Percent Composite Halftone Dot




Rapid Access 53.1 Percent Composite Halftone Dot



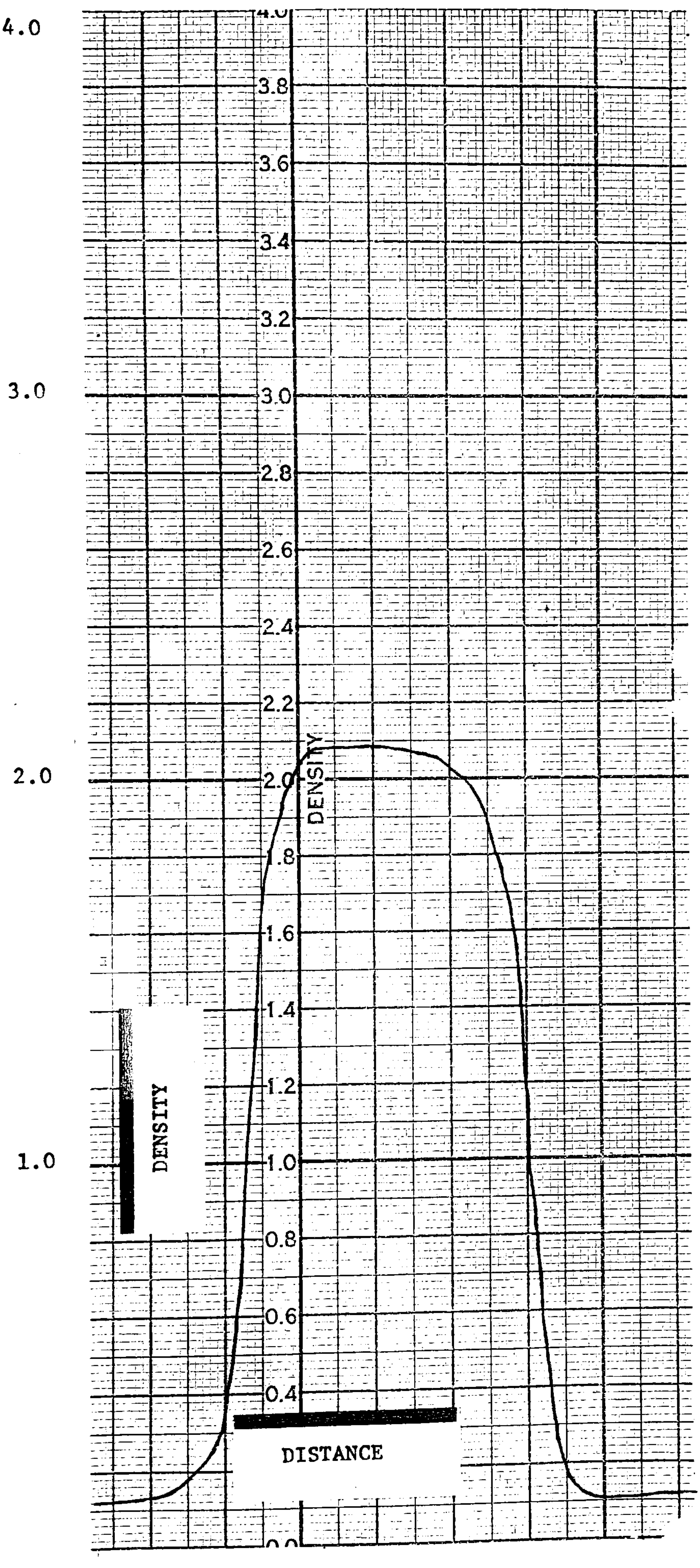

Lith 79.5 Percent Composite Halftone Dot



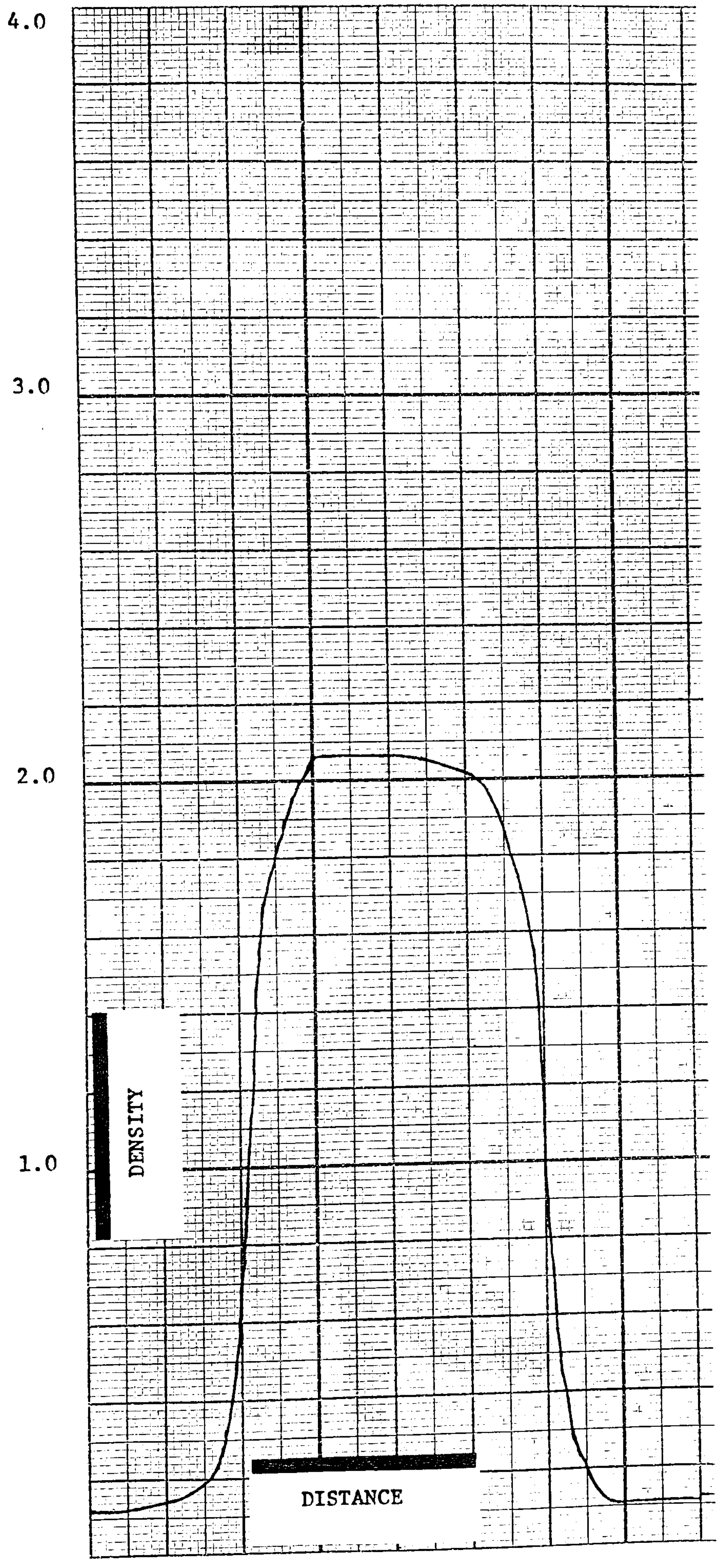

Rapid Access 84.6 Percent Composite Halftone Dot

# APPENDIX A6-B

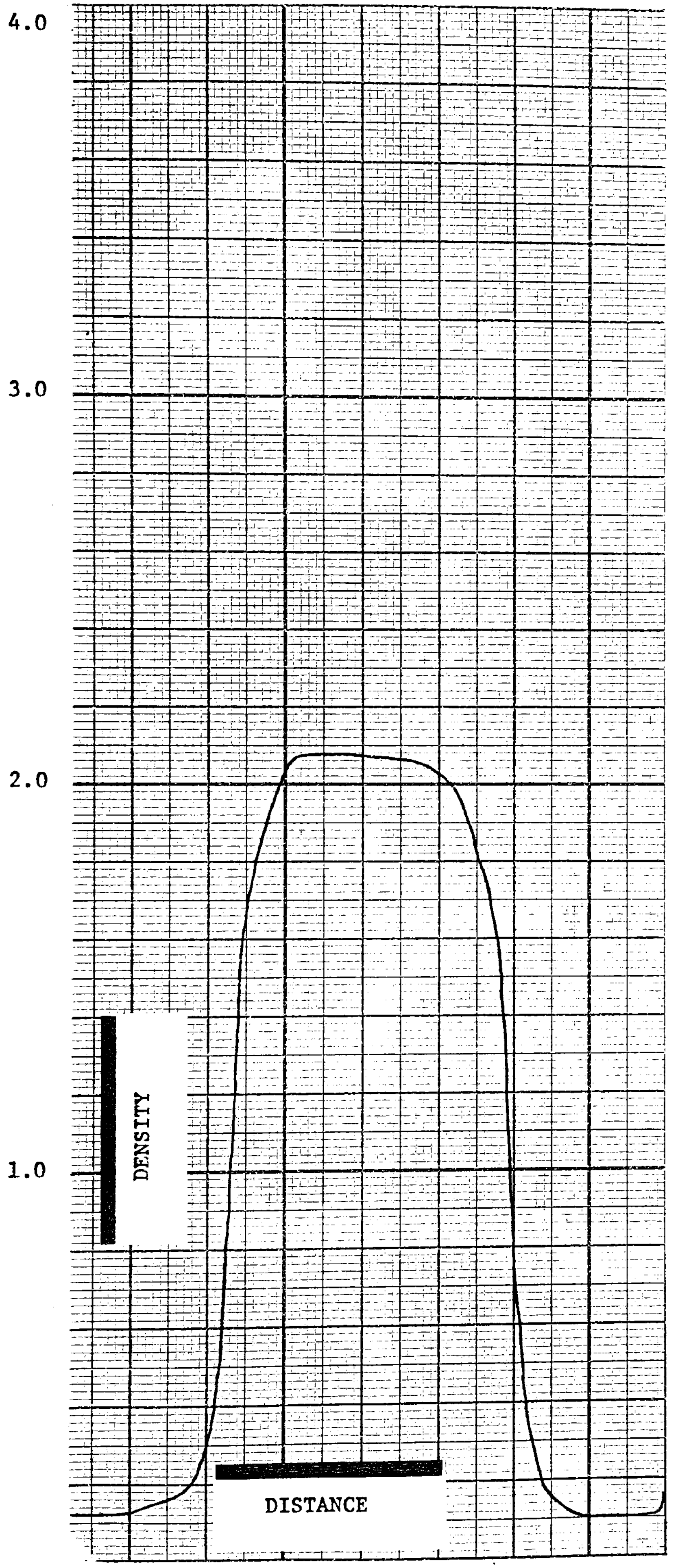
MICRODENSITOMETER ACTUAL TRACES OF LITH AND RAPID ACCESS HALFTONE DOTS



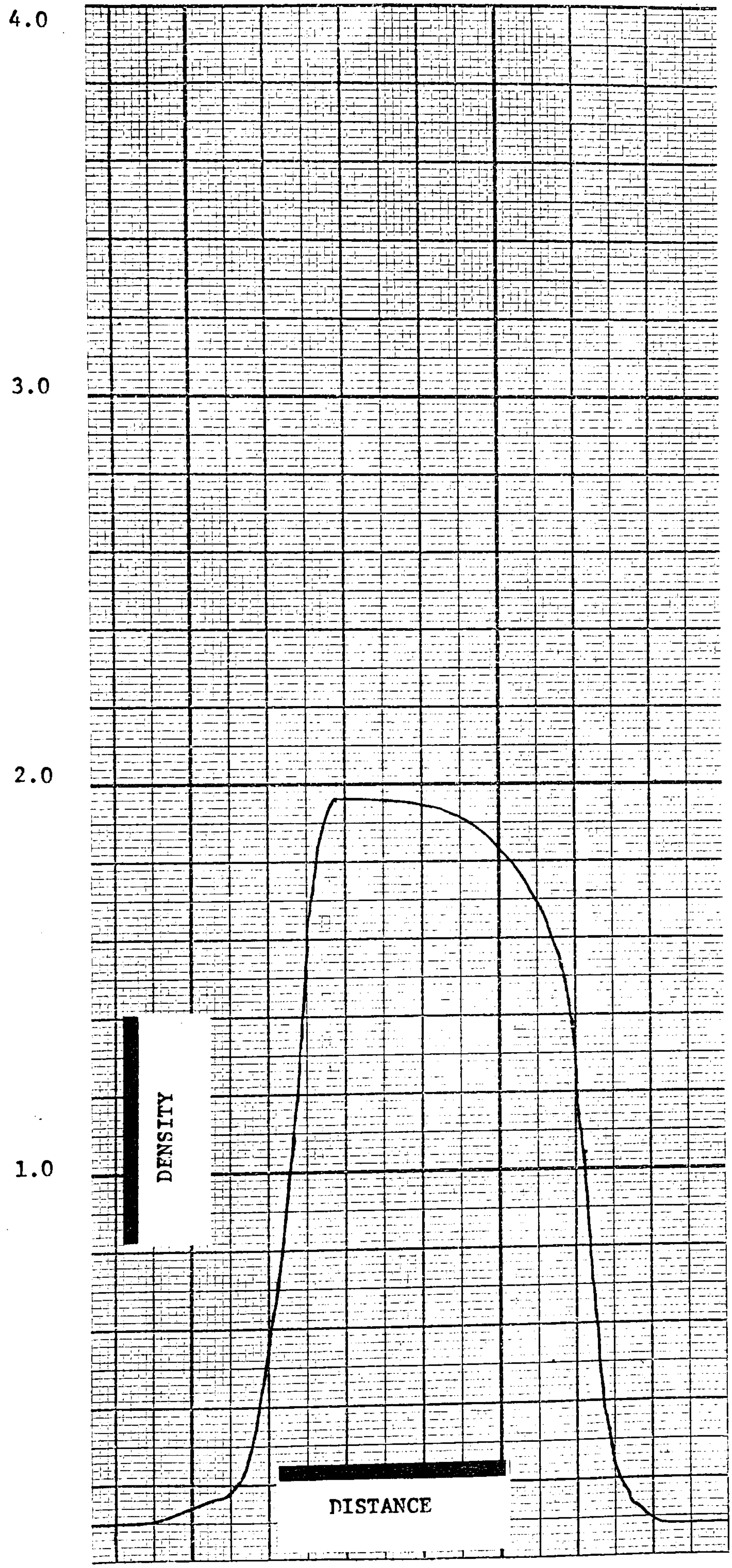

Lith 21.7 Percent Actual Halftone Dot



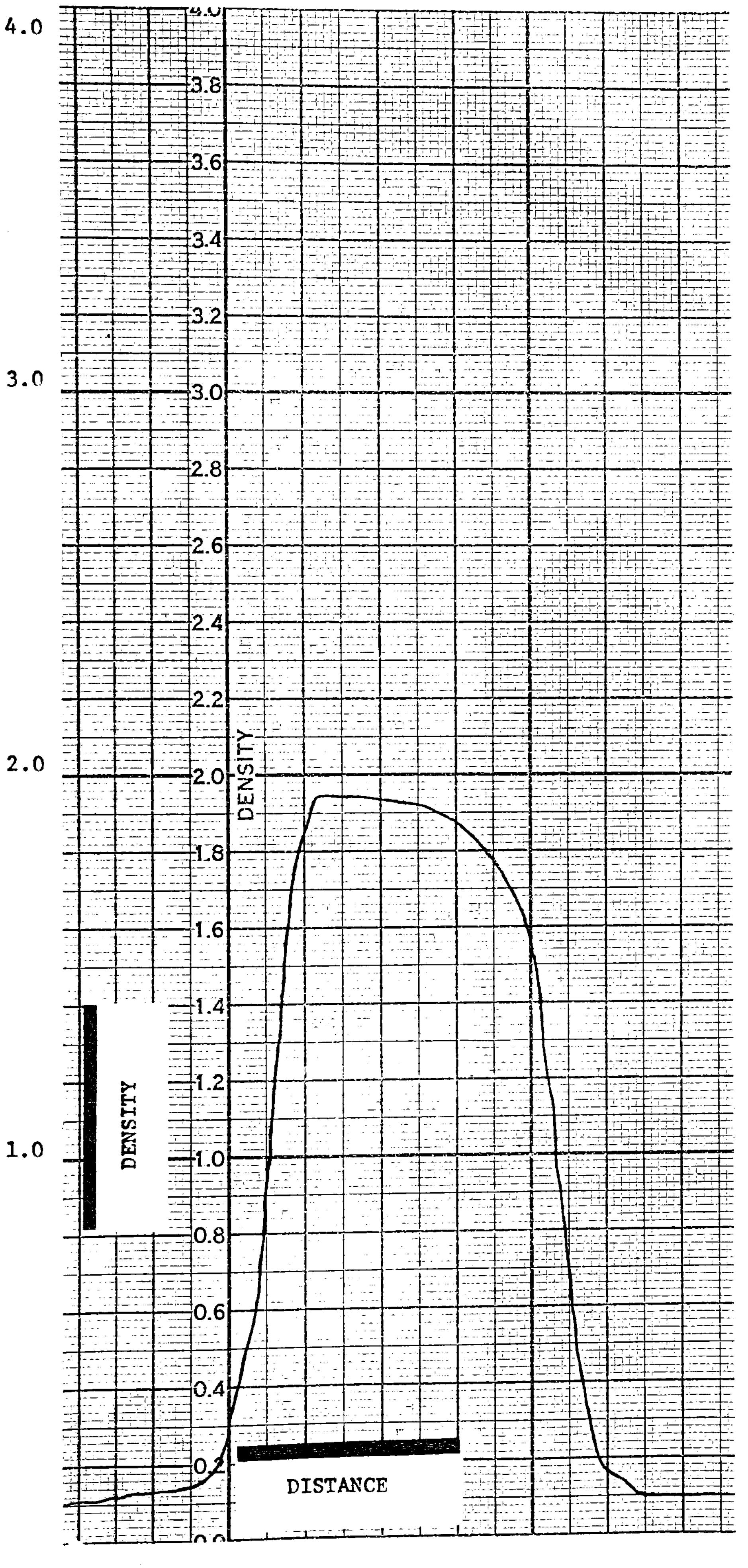

Lith 21.7 Percent Actual Halftone Dot



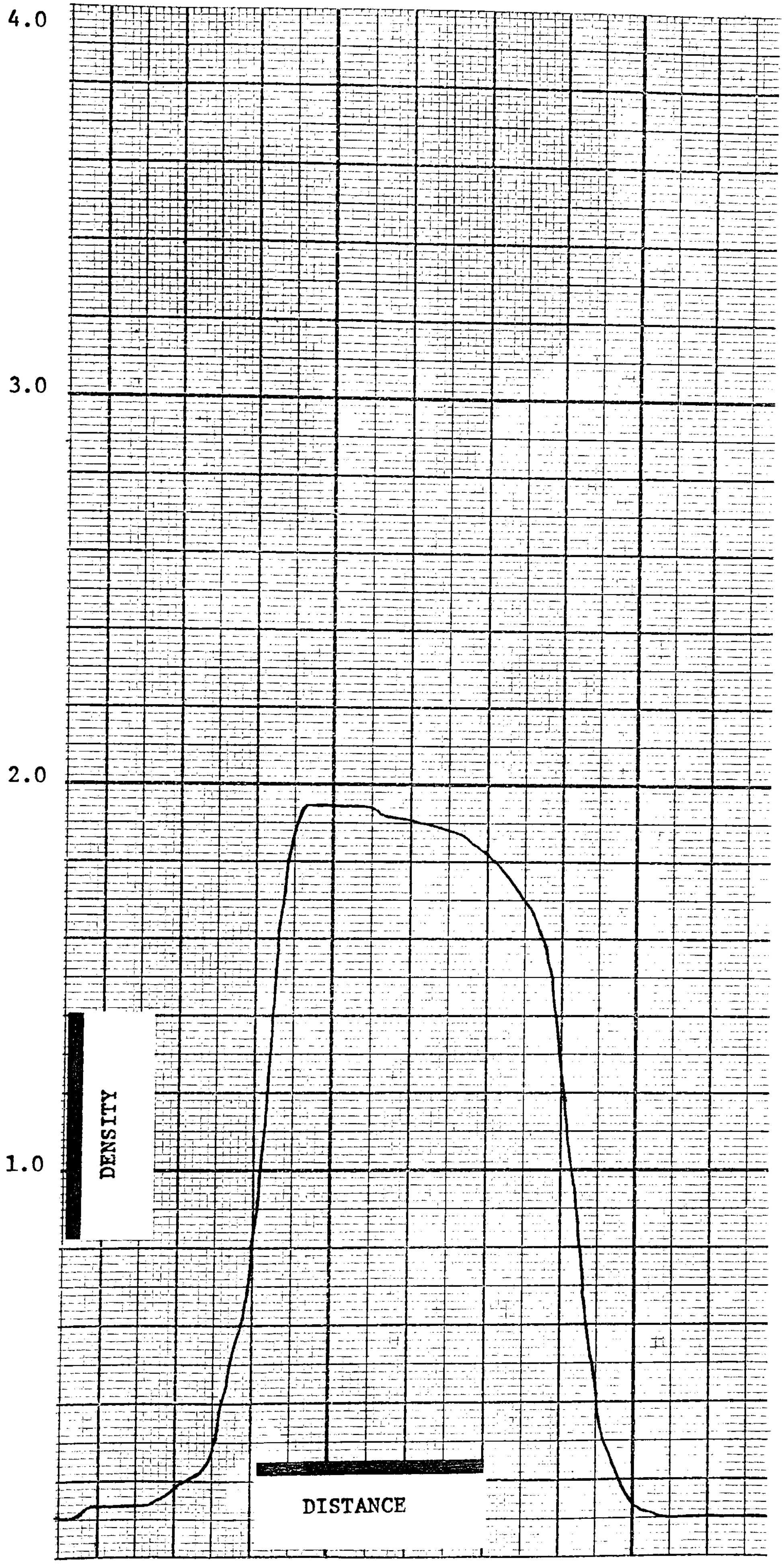

Lith 21.7 Percent Actual Halftone Dot



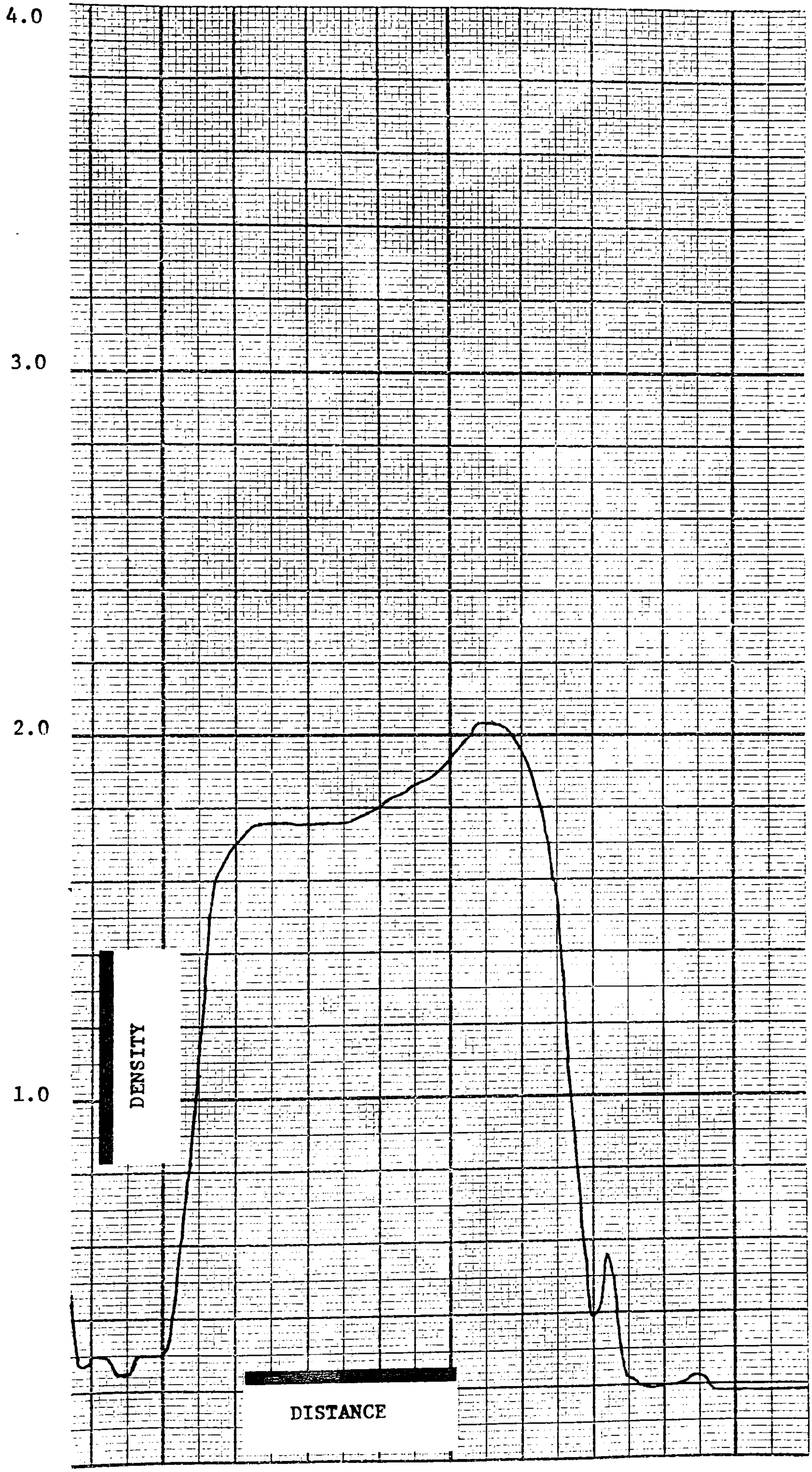

Rapid Access 24.3 Percent Actual Halftone Dot



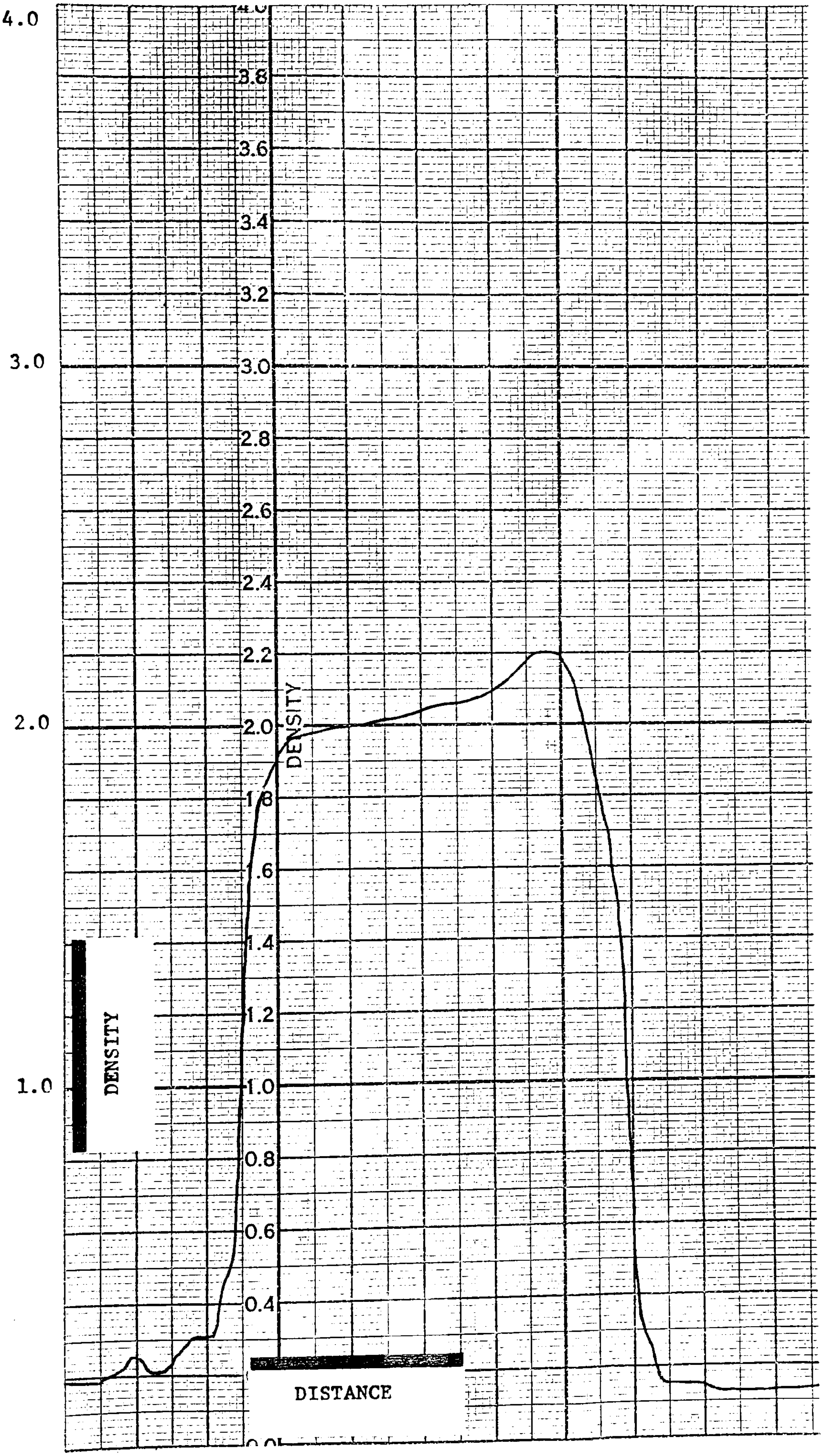

Rapid Access 24.3 Percent Actual Halftone Dot



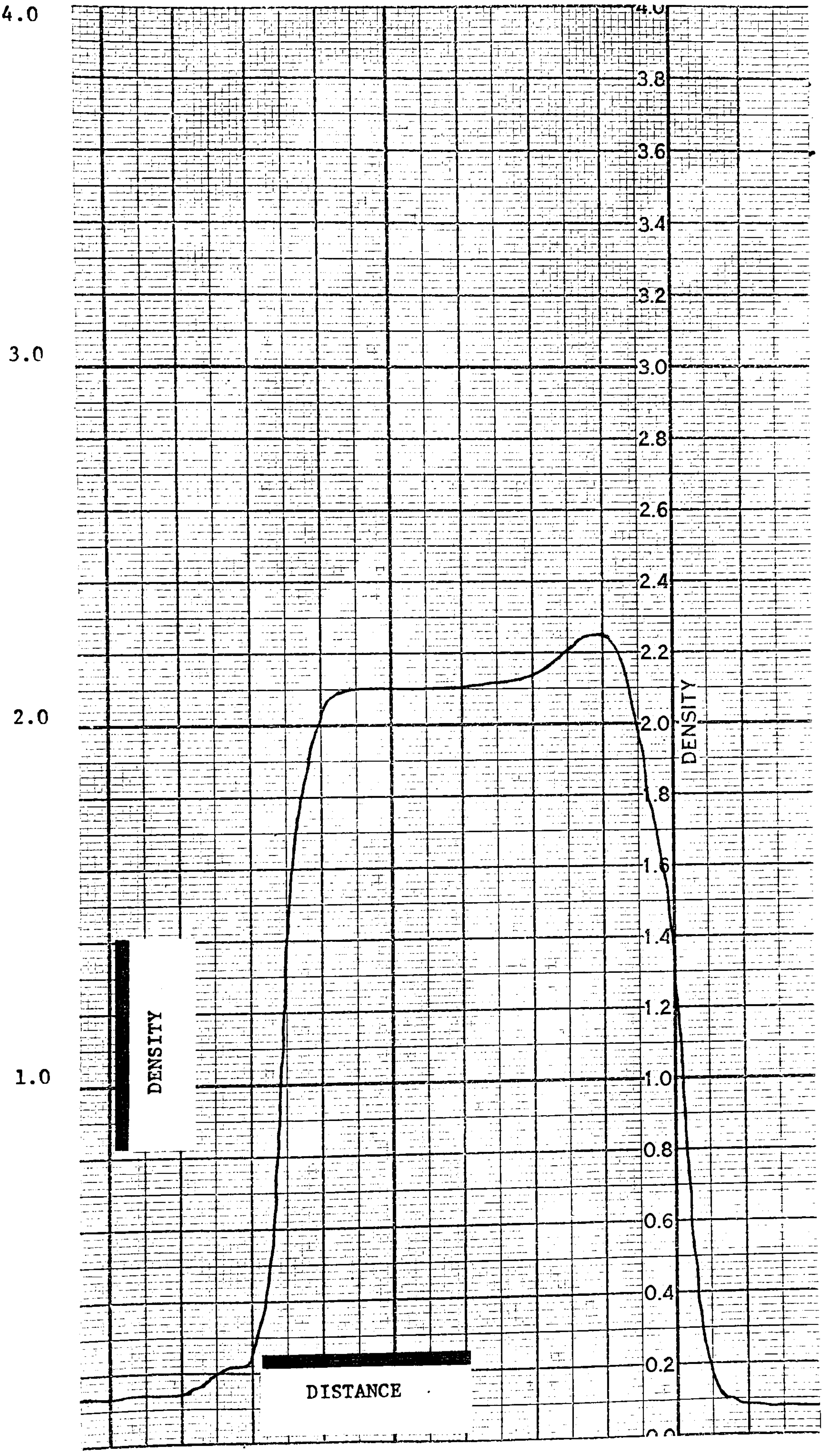

Rapid Access 24.3 Percent Actual Halftone Dot



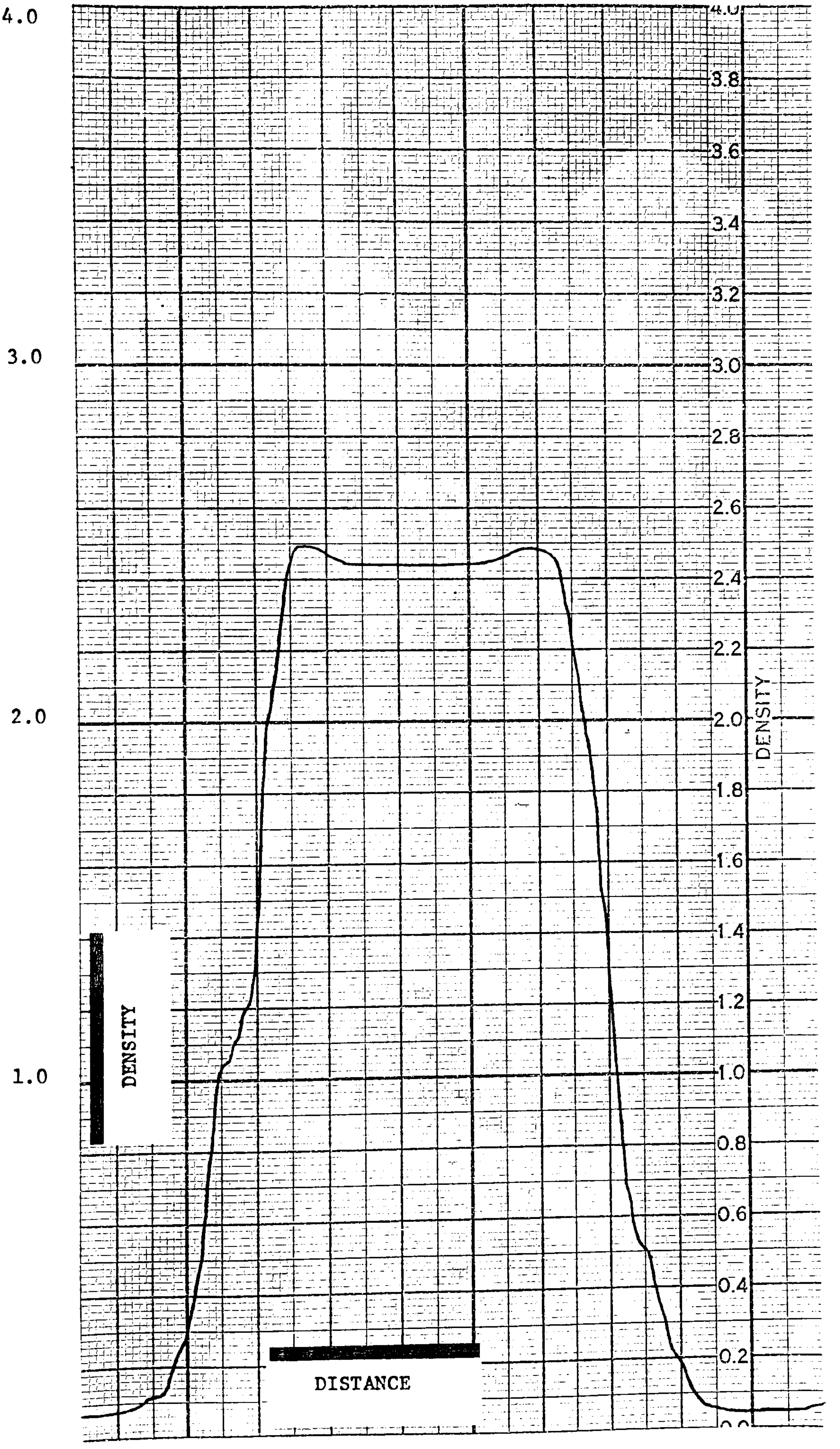

Lith 50.6 Percent Actual Halftone Dot



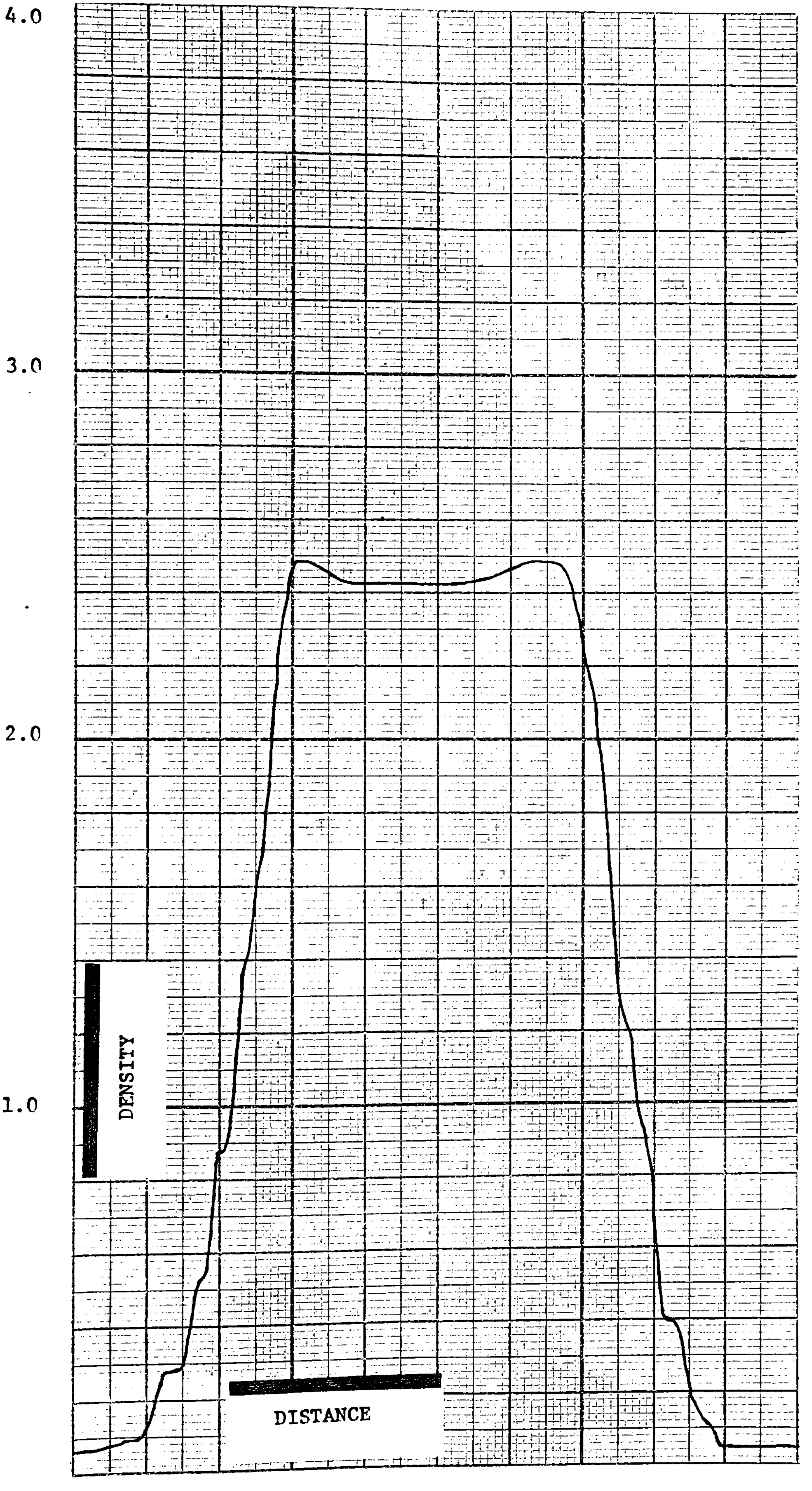

Lith 50.6 Percent Actual Halftone Dot



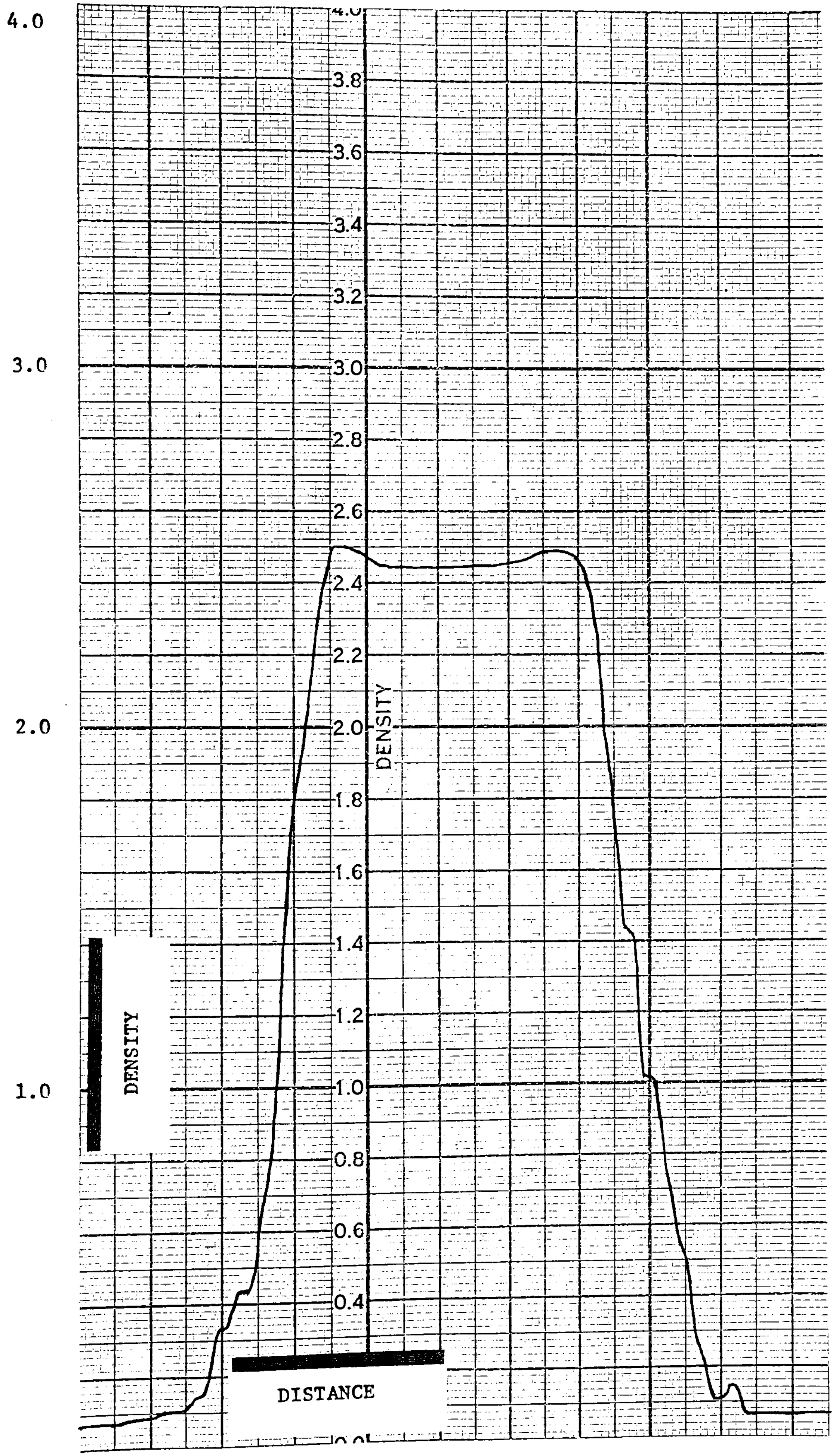

Lith 50.6 Percent Actual Halftone Dot



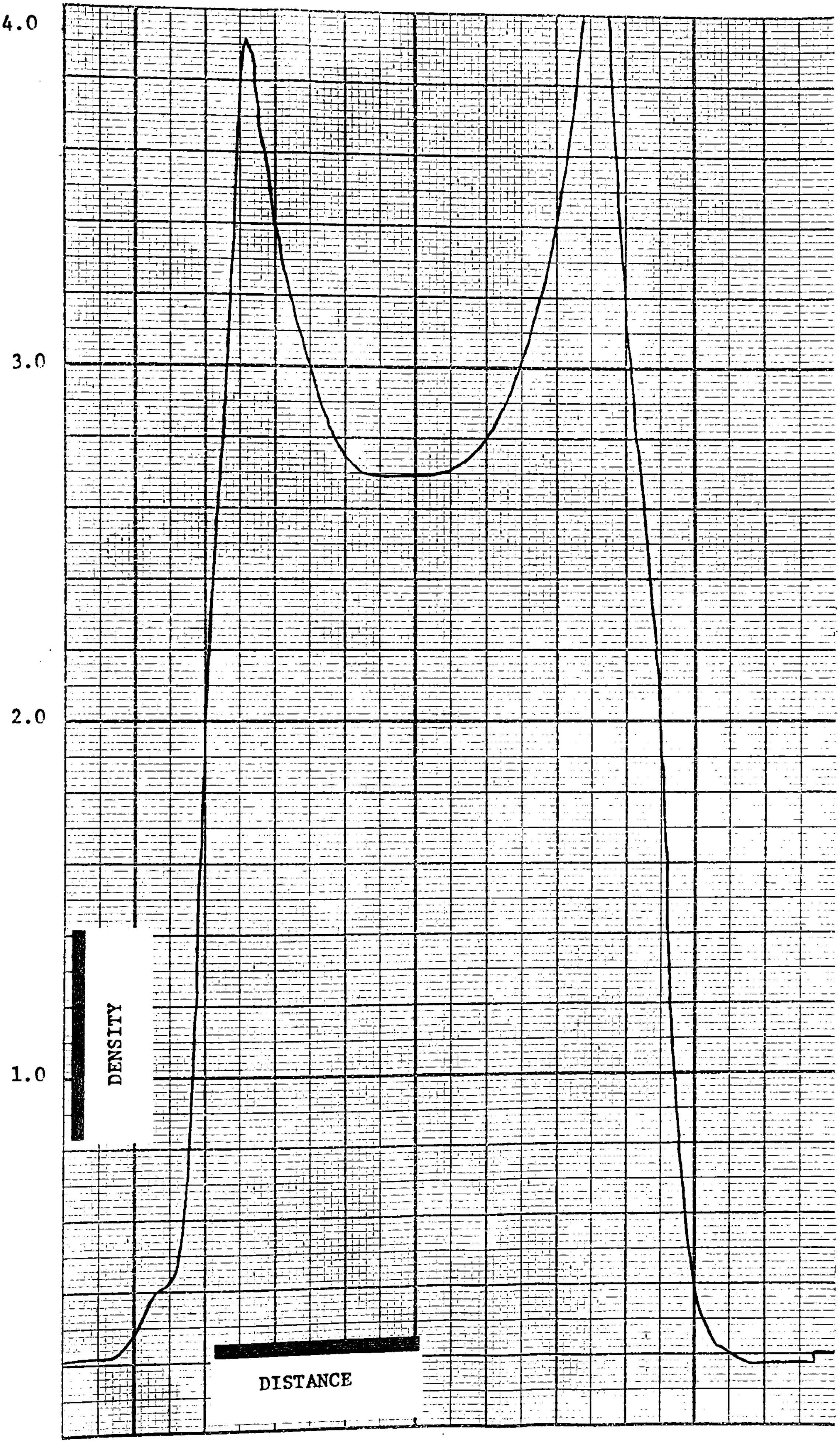

Rapid Access 53.1 Percent Actual Halftone Dot



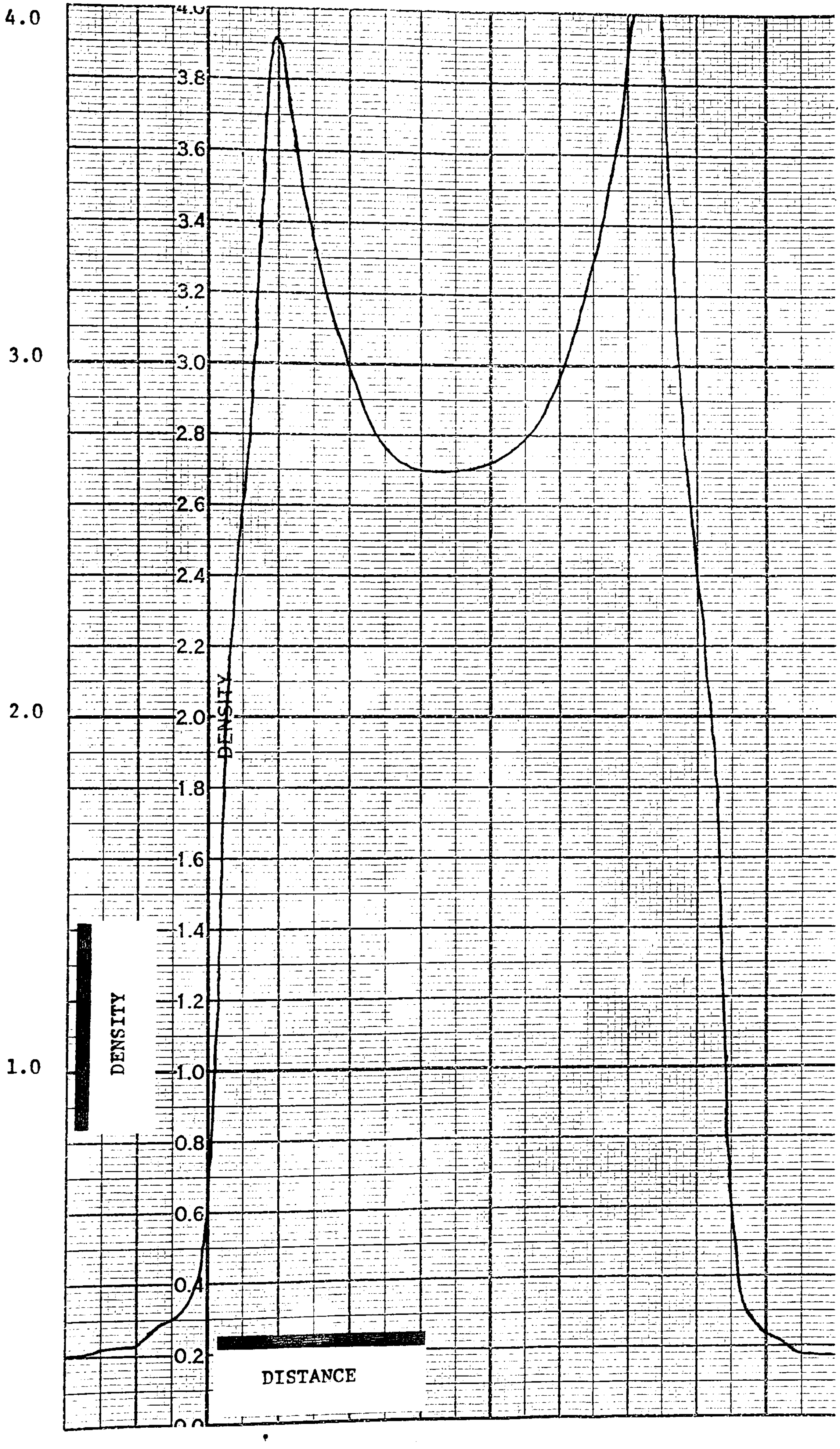

Rapid Access 53.1 Percent Actual Halftone Dot



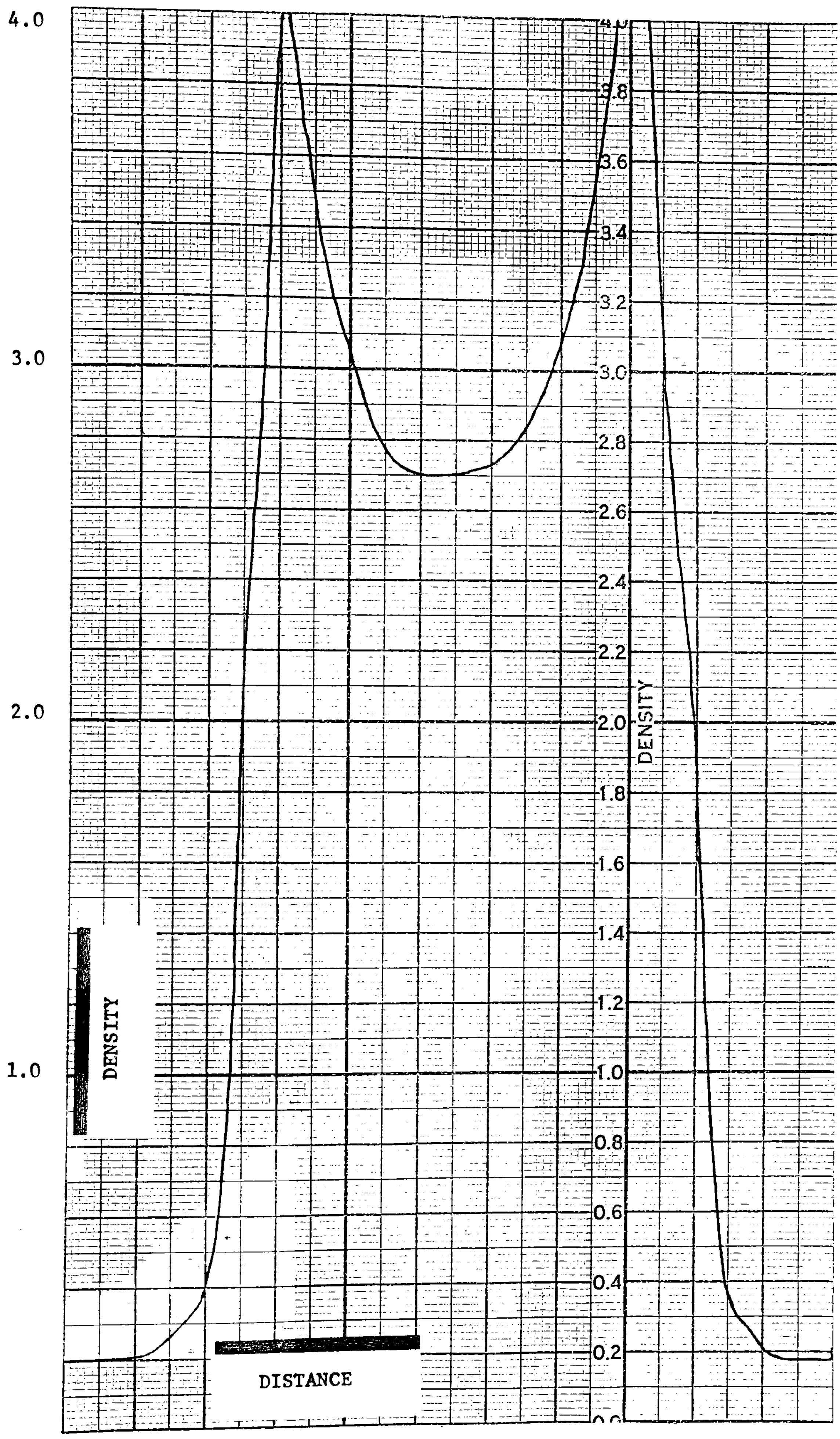

Rapid Access 53.1 Percent Actual Halftone Dot



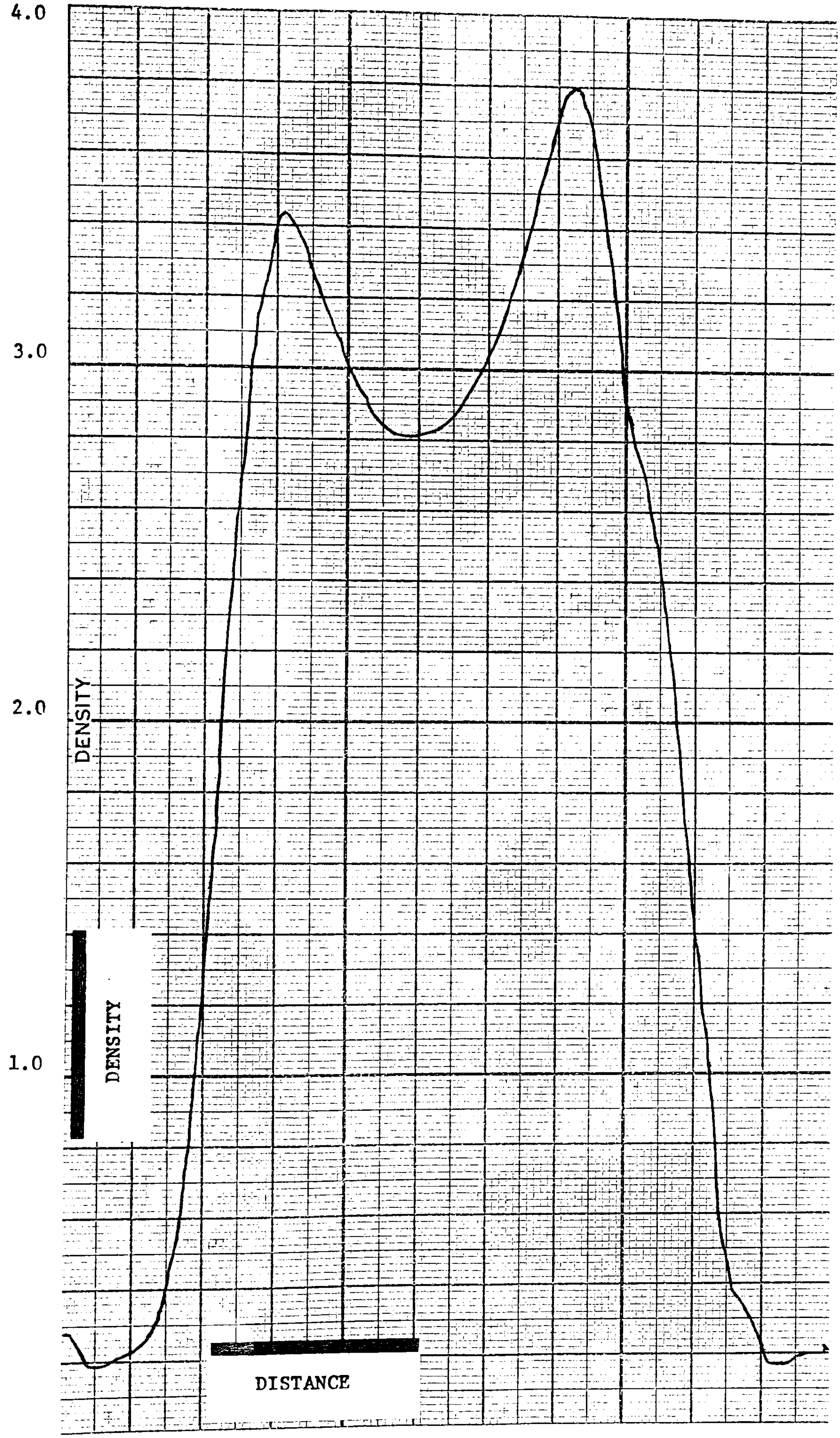

Lith 79.5 Percent Actual Halftone Dot



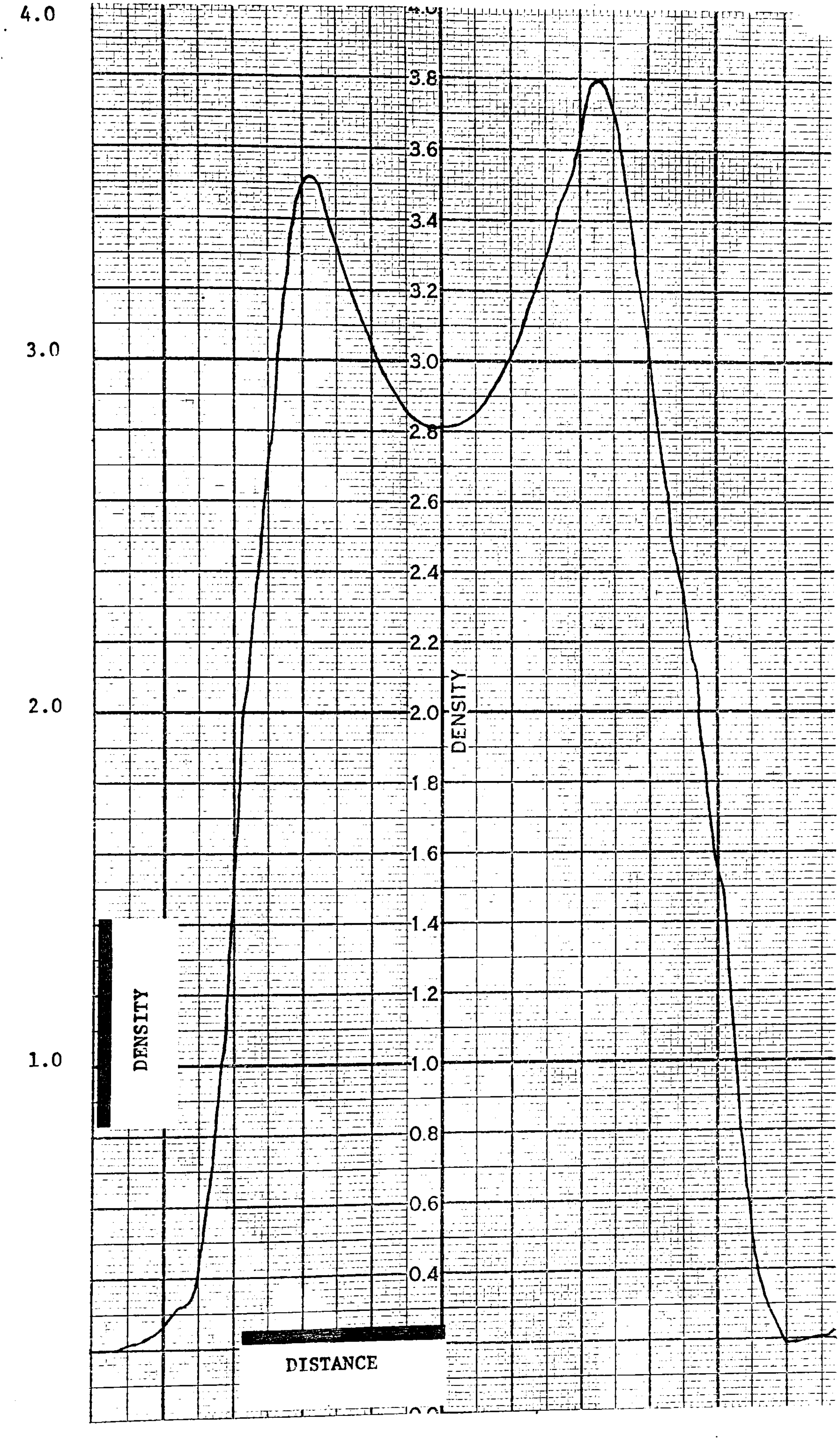

Lith 79.5 Percent Actual Halftone Dot



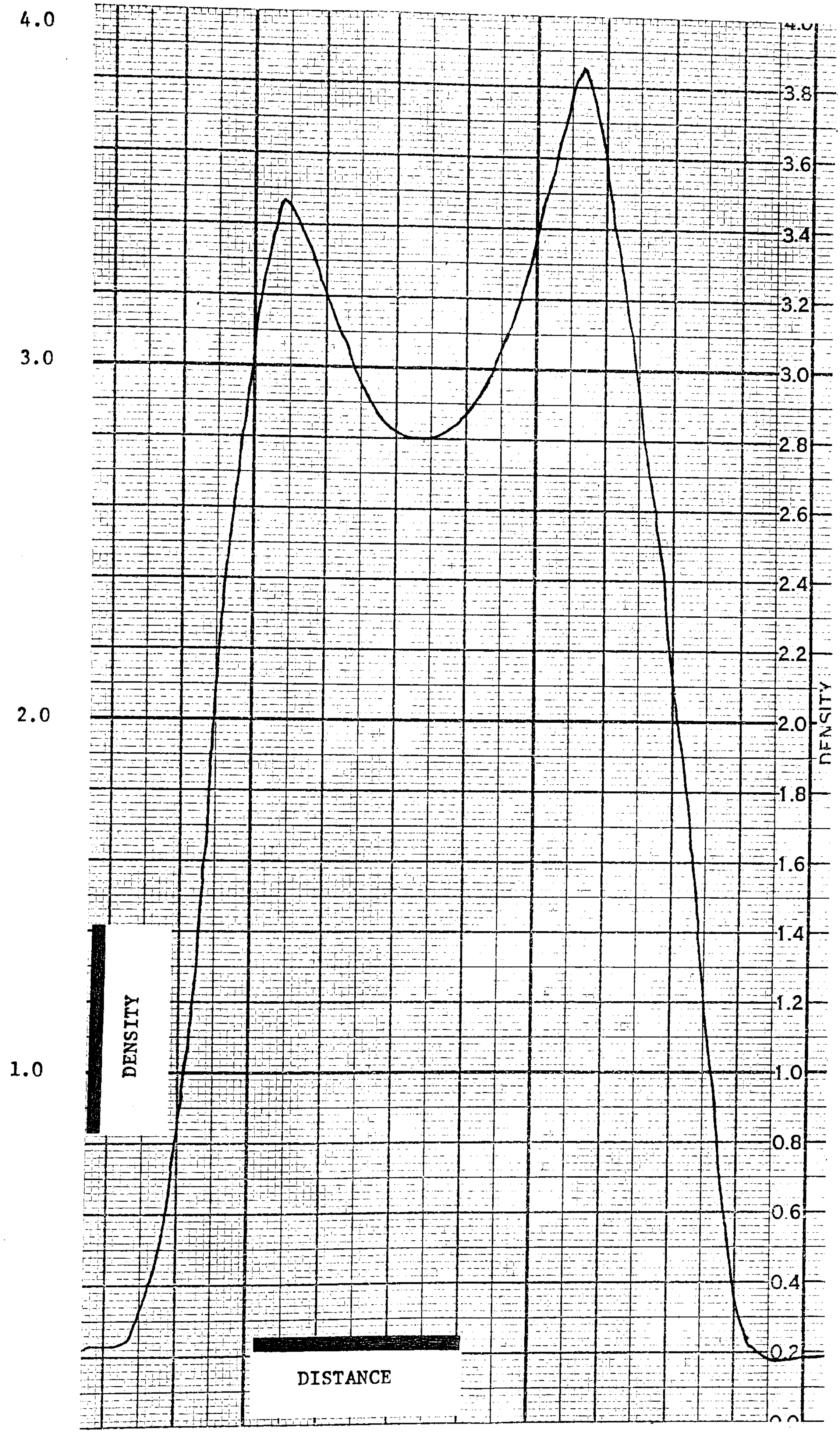

Lith 79.5 Percent Actual Halftone Dot




Rapid Access 84.6 Percent Actual Halftone Dot




Rapid Access 84.6 Percent Actual Halftone Dot




Rapid Access 84.6 Percent Actual Halftone Dot

# APPENDIX A7-A

CONTACT PERCENT DOT AREA FOR LITH SAMPLE PRODUCED BY OVER, NORMAL AND UNDER-EXPOSURE CONDITIONS

| Percent Dot Over-Exposure | Percent Dot Normal Exposure | Percent Dot Under-Exposure | Over-Exposure less Under-Exposure |
|---|---|---|---|
| 95.5 | 96.1 | 96.4 | .9 |
| 93.3 | 95.2 | 95.9 | 2.6 |
| 92.9 | 93.8 | 94.4 | 1.5 |
| 90.2 | 91.2 | 92.2 | 2.0 |
| 86.8 | 88.2 | 89.3 | 2.5 |
| 83.5 | 85.3 | 86.7 | 3.2 |
| 80.4 | 81.9 | 83.0 | 2.6 |
| 76.5 | 78.3 | 79.5 | 3.0 |
| 73.8 | 75.1 | 76.7 | 2.9 |
| 70.1 | 71.7 | 73.4 | 3.3 |
| 66.9 | 68.1 | 70.3 | 3.4 |
| 63.0 | 65.3 | 67.1 | 4.1 |
| 58.7 | 61.1 | 63.2 | 4.5 |
| 54.6 | 57.4 | 59.6 | 5.0 |
| 50.1 | 53.1 | 55.3 | 5.2 |
| 46.3 | 48.5 | 50.6 | 4.3 |
| 43.3 | 45.9 | 48.0 | 4.7 |
| 38.4 | 41.4 | 43.6 | 5.2 |
| 33.5 | 37.2 | 38.2 | 4.7 |
| 31.4 | 33.4 | 36.1 | 4.7 |
| 27.5 | 29.1 | 31.5 | 4.0 |
| 23.4 | 24.9 | 26.9 | 3.5 |
| 18.4 | 20.1 | 21.7 | 3.3 |
| 13.4 | 14.8 | 16.4 | 3.0 |
| 8.7 | 10.0 | 11.4 | 2.7 |
| 5.2 | 6.5 | 7.9 | 2.7 |

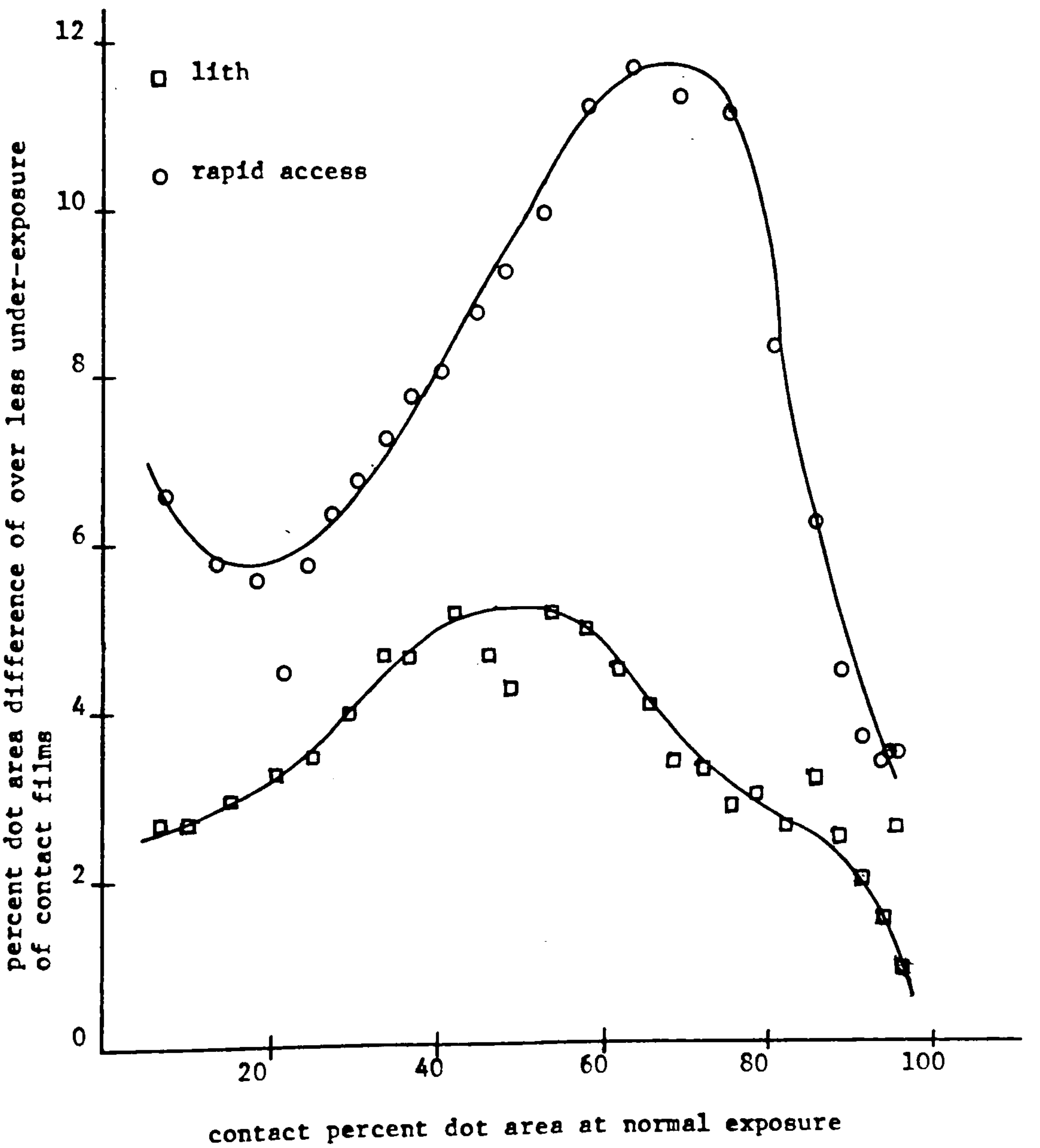
APPENDIX A7-B

CONTACT PERCENT DOT AREA FOR RAPID ACCESS SAMPLE PRODUCED BY OVER, NORMAL AND UNDER-EXPOSURE CONDITIONS

| Percent Dot Over-Exposure | Percent Dot Normal Exposure | Percent Dot Under-Exposure | Over-Exposure less Under-Exposure |
|---|---|---|---|
| 93.9 | 95.4 | 97.4 | 3.5 |
| 93.1 | 94.8 | 96.6 | 3.5 |
| 92.0 | 93.5 | 95.4 | 3.4 |
| 89.7 | 91.4 | 93.4 | 3.7 |
| 86.4 | 88.7 | 90.9 | 4.5 |
| 81.9 | 85.3 | 88.2 | 6.3 |
| 76.2 | 80.5 | 84.6 | 8.4 |
| 69.8 | 75.2 | 81.0 | 11.2 |
| 63.6 | 69.2 | 75.0 | 11.4 |
| 57.4 | 63.2 | 69.2 | 11.8 |
| 51.8 | 57.9 | 63.1 | 11.3 |
| 47.5 | 52.4 | 57.5 | 10.0 |
| 43.8 | 47.9 | 53.1 | 9.3 |
| 39.7 | 44.6 | 48.5 | 8.8 |
| 36.2 | 40.2 | 44.3 | 8.1 |
| 32.4 | 36.6 | 40.2 | 7.8 |
| 29.7 | 33.8 | 37.0 | 7.3 |
| 26.5 | 30.2 | 33.3 | 6.8 |
| 23.2 | 27.3 | 29.6 | 6.4 |
| 21.7 | 24.1 | 27.5 | 5.8 |
| 19.8 | 21.4 | 24.3 | 4.5 |
| 15.5 | 18.2 | 21.1 | 5.6 |
| 10.9 | 13.3 | 16.7 | 5.8 |
| 3.3 | 7.2 | 10.9 | 6.6 |

APPENDIX A7-C

FRINGE DIFFERENCES OF RAPID ACCESS AND LITH FIRST GENERATION HALFTONE FILMS PRODUCED BY OVER AND UNDER-EXPOSURE CONTACT EXPOSURES



# APPENDIX B

## MEASUREMENT OF EFFECTIVE PRINTING DOT OF RAPID ACCESS HALFTONES BY METER ZEROING ON THE GHOST DOT

APPENDIX B1

DIFFERENCES BETWEEN GHOST PERCENT DOT AREA OF FIRST GENERATION FILMS AND CONTACT SECOND GENERATION HARD DOT

| | Main Exposure | | | Main and Flash Exposure | | | Main Flash and Bump Exposure | |
|---|---|---|---|---|---|---|---|---|
| Ghost | Hard | Diff. | Ghost | Hard | Diff. | Ghost | Hard | Diff. |
| 99.8 | 98.6 | 1.2 | 98.1 | 93.0 | 5.1 | 98.9 | 94.8 | 4.1 |
| 99.7 | 98.0 | 1.7 | 98.0 | 92.6 | 5.4 | 98.7 | 92.7 | 6.0 |
| 99.5 | 97.0 | 2.5 | 97.1 | 91.3 | 5.8 | 97.9 | 85.7 | 12.2 |
| 99.0 | 94.9 | 4.1 | 95.6 | 89.1 | 6.5 | 95.7 | 71.7 | 24.0 |
| 97.8 | 92.9 | 4.9 | 93.5 | 85.8 | 7.7 | 91.3 | 55.3 | 36.0 |
| 96.2 | 90.0 | 6.2 | 91.0 | 81.7 | 9.3 | 85.1 | 44.0 | 41.1 |
| 94.1 | 87.0 | 7.1 | 87.9 | 76.2 | 11.7 | 77.6 | 37.6 | 40.0 |
| 91.5 | 83.3 | 8.2 | 84.5 | 70.6 | 13.9 | 69.1 | 32.7 | 36.4 |
| 88.9 | 78.0 | 10.9 | 80.5 | 64.3 | 16.2 | 61.7 | 29.2 | 32.5 |
| 85.8 | 72.6 | 13.2 | 77.0 | 59.5 | 17.5 | 55.1 | 26.7 | 28.4 |
| 82.1 | 67.4 | 14.7 | 72.6 | 54.2 | 18.4 | 49.2 | 24.7 | 24.5 |
| 77.9 | 61.2 | 16.7 | 67.9 | 49.9 | 20.7 | 43.5 | 22.8 | 20.7 |
| 73.5 | 55.2 | 18.3 | 63.9 | 46.3 | 17.6 | 39.0 | 21.7 | 17.3 |
| 69.2 | 50.9 | 18.3 | 58.8 | 43.5 | 15.3 | 35.8 | 20.7 | 15.1 |
| 64.4 | 46.9 | 17.5 | 54.7 | 40.2 | 14.5 | 31.6 | 19.7 | 11.9 |
| 58.5 | 42.4 | 16.1 | 49.8 | 37.4 | 12.4 | 28.4 | 18.6 | 9.8 |
| 54.2 | 39.8 | 14.4 | 47.1 | 35.1 | 12.0 | 25.9 | 18.0 | 7.9 |
| 47.9 | 35.8 | 12.1 | 42.4 | 32.2 | 10.2 | 23.5 | 17.4 | 6.1 |
| 41.6 | 31.8 | 9.8 | 38.3 | 30.0 | 8.3 | 21.7 | 16.7 | 5.0 |
| 38.1 | 28.8 | 9.3 | 34.4 | 27.6 | 6.8 | 20.3 | 16.2 | 4.1 |
| 31.8 | 26.1 | 5.7 | 31.5 | 28.8 | 2.7 | 18.5 | 15.6 | 2.9 |
| 26.0 | 22.7 | 3.3 | 28.0 | 24.2 | 3.8 | 17.3 | 15.0 | 2.3 |
| 17.9 | 18.1 | -.2 | 22.6 | 21.3 | 1.3 | 15.2 | 14.0 | 1.2 |
| 9.3 | 13.0 | -3.7 | 18.0 | 18.4 | -.4 | 13.9 | 13.5 | .4 |
| 1.1 | 5.5 | -4.4 | 14.0 | 16.0 | -2.0 | 12.5 | 12.9 | -.4 |
| - | - | - | 10.7 | 13.6 | -2.9 | 11.5 | 12.6 | -1.1 |
| - | - | - | 7.6 | 11.5 | -3.9 | 11.1 | 12.4 | -1.3 |
| - | - | - | 5.8 | 10.0 | -4.2 | 10.6 | 12.1 | -1.5 |
| - | - | - | 3.9 | 8.3 | -4.4 | 10.1 | 11.8 | -1.7 |
| - | - | - | 2.9 | 7.0 | -4.1 | 9.8 | 11.5 | -1.7 |

# APPENDIX C

## FRINGE COMPENSATION METHOD FOR DETERMINING EFFECTIVE PRINTING DOT

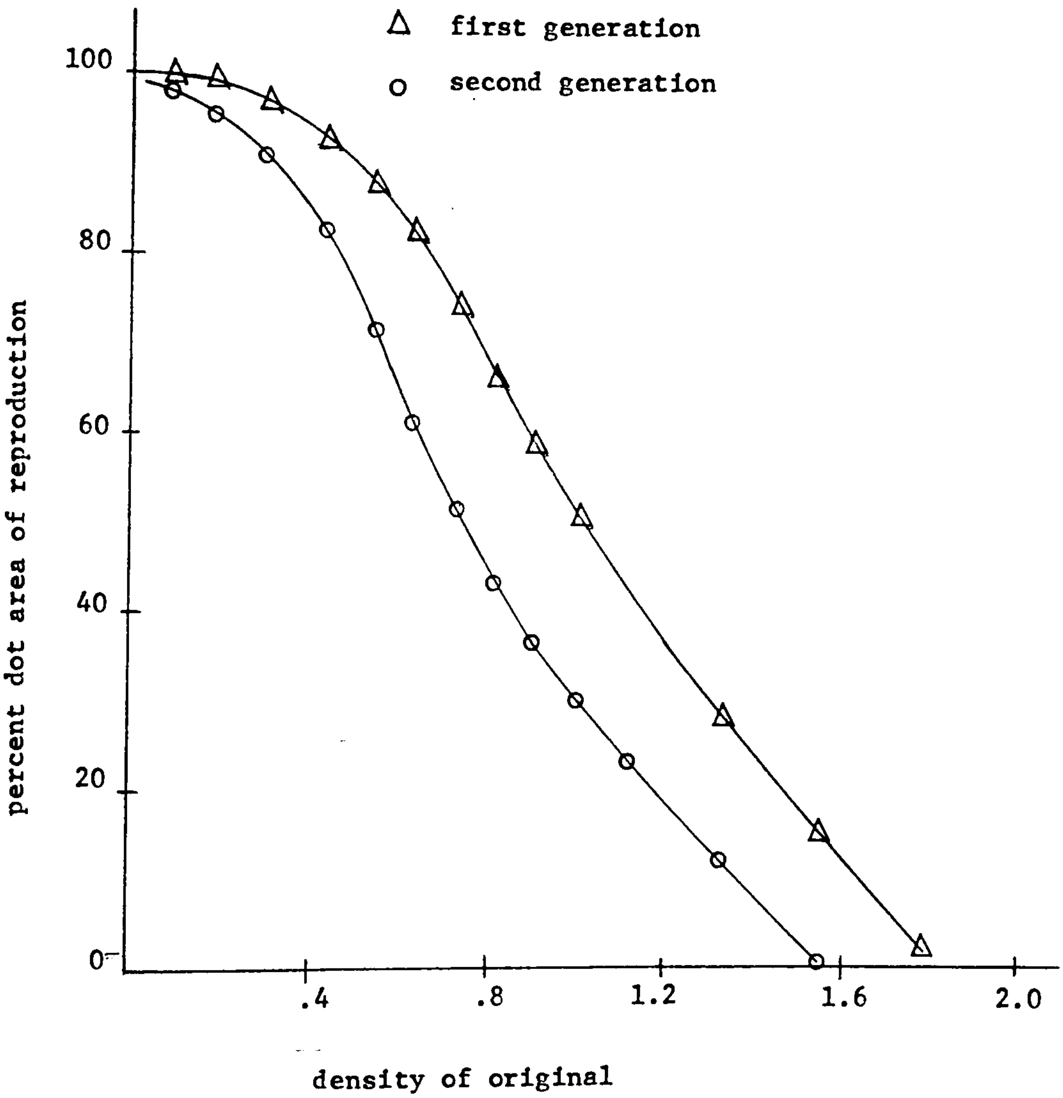
# APPENDIX C1

PERCENT DOT AREA MEASUREMENTS OF FIRST GENERATION SOFT DOT HALFTONE FILMS AND THEIR RESPECTIVE SECOND GENERATION HARD DOT CONTACT FILMS PRODUCED BT THREE DIFFERENT EXPOSURE CONDITIONS

| Density of Original | Main Exposure | | | Main and Flash Exposure | | | Main, Flash & Bump Exposure | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soft | Hard | Diff. | Soft | Hard | Diff. | Soft | Hard | Diff. |
| .04 | 99.7 | 98.6 | 1.1 | 98.5 | 93.0 | 5.5 | 99.1 | 94.8 | 4.3 |
| .09 | 99.7 | 98.0 | 1.7 | 98.3 | 92.6 | 5.7 | 98.9 | 92.7 | 6.2 |
| .12 | 99.5 | 97.0 | 2.5 | 97.6 | 91.3 | 6.3 | 98.2 | 85.7 | 12.5 |
| .18 | 99.1 | 94.9 | 4.2 | 96.5 | 89.1 | 7.4 | 96.5 | 71.7 | 24.8 |
| .23 | 98.2 | 92.9 | 5.3 | 94.7 | 85.8 | 8.9 | 93.0 | 55.3 | 37.7 |
| .30 | 96.9 | 90.9 | 6.9 | 92.7 | 81.7 | 11.0 | 88.1 | 44.0 | 44.1 |
| .37 | 95.3 | 87.0 | 8.3 | 90.3 | 76.2 | 14.1 | 82.1 | 37.6 | 44.5 |
| .43 | 93.2 | 83.3 | 9.9 | 87.5 | 70.6 | 16.9 | 75.5 | 32.7 | 42.8 |
| .48 | 91.3 | 78.0 | 13.3 | 84.5 | 64.3 | 20.2 | 69.8 | 29.2 | 40.6 |
| .54 | 88.8 | 72.6 | 16.2 | 81.4 | 59.5 | 21.9 | 64.6 | 26.7 | 37.9 |
| .58 | 86.1 | 67.4 | 18.7 | 77.9 | 54.2 | 23.7 | 59.5 | 24.7 | 34.8 |
| .63 | 82.7 | 61.2 | 21.5 | 74.3 | 49.9 | 24.4 | 54.8 | 22.8 | 32.0 |
| .68 | 79.0 | 55.2 | 23.8 | 71.0 | 46.3 | 24.7 | 51.6 | 21.7 | 29.9 |
| .73 | 75.5 | 50.9 | 24.6 | 67.9 | 43.5 | 24.4 | 48.1 | 20.7 | 27.4 |
| .77 | 71.6 | 46.9 | 24.7 | 64.1 | 40.2 | 23.9 | 45.4 | 19.7 | 25.7 |
| .82 | 66.7 | 42.4 | 24.3 | 60.2 | 37.4 | 22.8 | 42.8 | 18.6 | 24.2 |
| .86 | 63.3 | 39.8 | 23.5 | 57.8 | 35.1 | 22.7 | 41.3 | 18.0 | 23.3 |
| .91 | 58.4 | 35.8 | 22.6 | 54.5 | 32.2 | 22.3 | 39.4 | 17.4 | 22.0 |
| .96 | 53.4 | 31.8 | 21.6 | 51.0 | 30.0 | 21.0 | 37.8 | 16.7 | 21.1 |
| 1.01 | 50.6 | 28.8 | 21.8 | 49.0 | 27.6 | 21.4 | 36.8 | 16.2 | 20.6 |
| 1.07 | 46.2 | 26.1 | 20.1 | 45.9 | 28.8 | 17.1 | 35.3 | 15.6 | 19.7 |
| 1.12 | 41.2 | 22.7 | 18.5 | 43.5 | 24.2 | 19.3 | 34.4 | 15.0 | 19.4 |
| 1.22 | 33.8 | 18.1 | 15.7 | 39.6 | 21.3 | 18.3 | 32.8 | 14.0 | 18.8 |
| 1.33 | 27.9 | 13.0 | 14.9 | 35.0 | 18.4 | 16.6 | 31.4 | 13.5 | 17.9 |
| 1.44 | 21.4 | 5.5 | 15.9 | 31.6 | 16.0 | 15.6 | 30.5 | 12.9 | 17.6 |
| 1.55 | 15.2 | .2 | 15.0 | 29.1 | 13.6 | 15.5 | 29.8 | 12.6 | 17.2 |
| 1.66 | 10.3 | .1 | 10.2 | 26.9 | 11.5 | 15.4 | 29.3 | 12.4 | 16.9 |
| 1.79 | 5.8 | - | - | 25.2 | 10.0 | 15.2 | 29.0 | 12.1 | 16.9 |
| 1.90 | 3.2 | - | - | 23.7 | 8.3 | 15.4 | 28.6 | 11.8 | 16.8 |
| 2.04 | 1.9 | - | - | 22.9 | 7.0 | 15.9 | 28.3 | 11.5 | 16.8 |

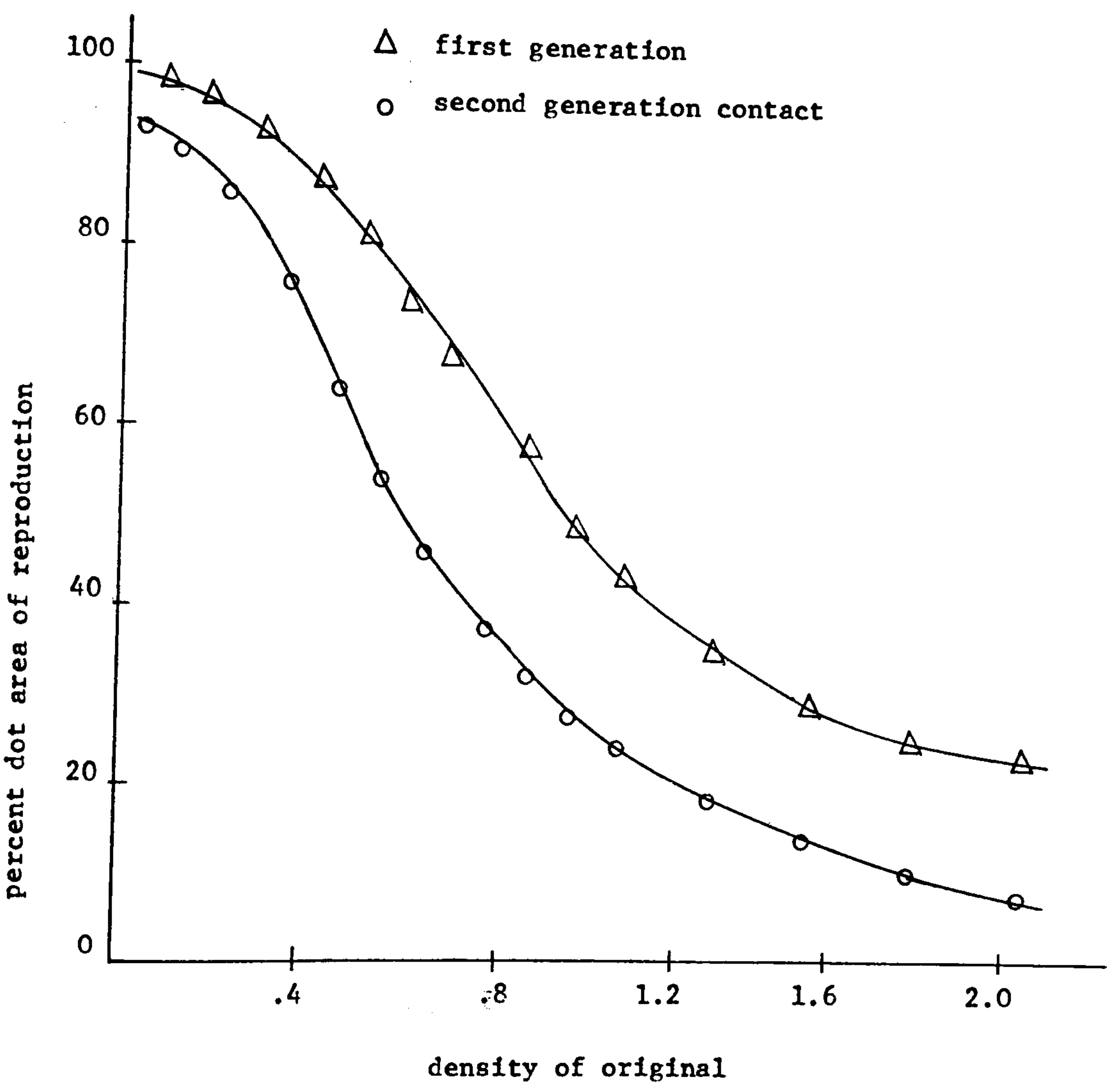
APPENDIX C2-A

PERCENT DOT AREA OF FIRST GENERATION HALFTONE FILM AND SECOND GENERATION CONTACT FILM PRODUCED BY A MAIN EXPOSURE



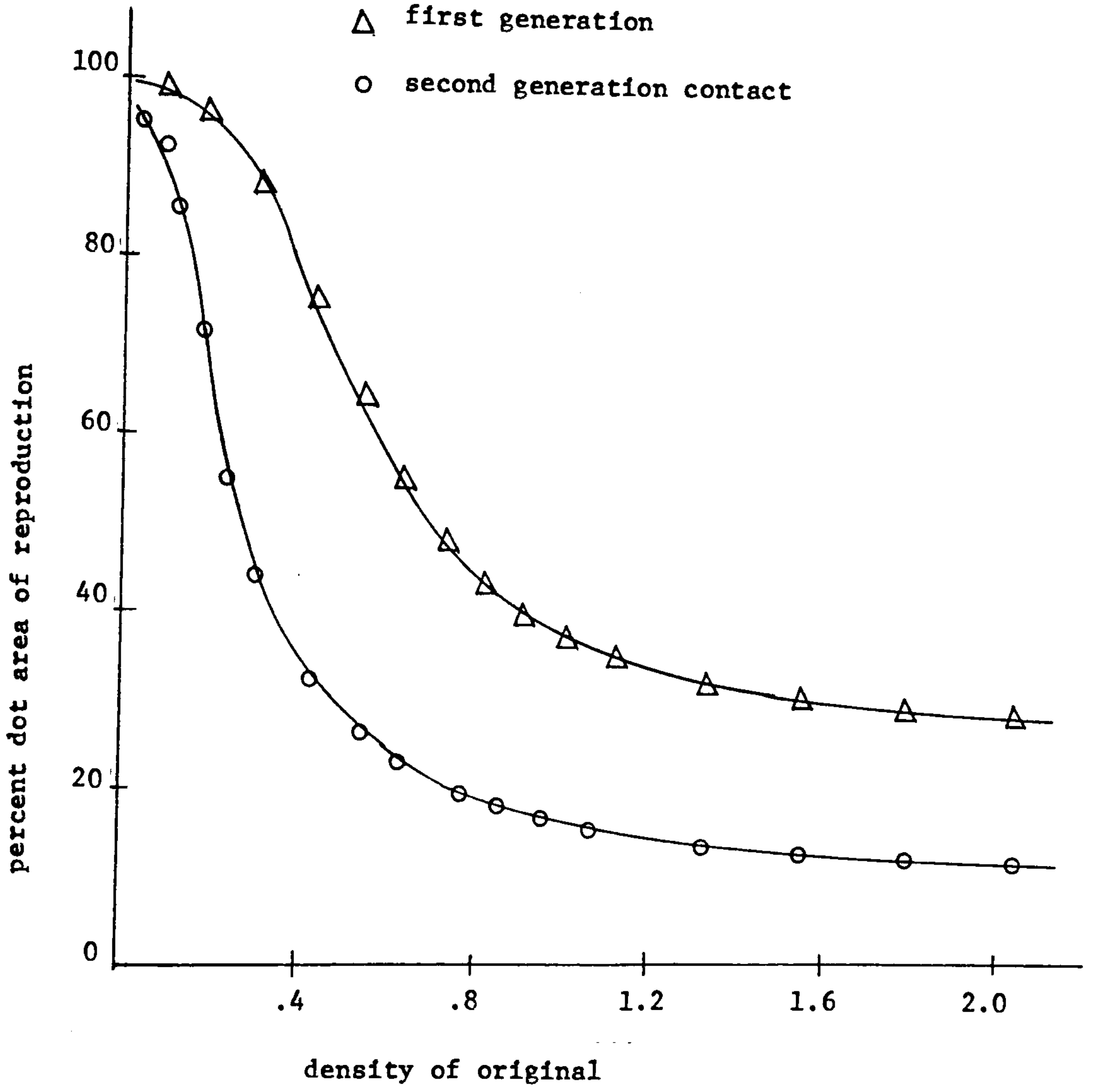
APPENDIX C2-B

PERCENT DOT AREA OF FIRST GENERATION HALFTONE FILM AND SECOND GENERATION CONTACT FILM PRODUCED BY A MAIN AND FLASH EXPOSURE



APPENDIX C2-C

PERCENT DOT AREA OF FIRST GENERATION HALFTONE FILM AND SECOND GENERATION CONTACT FILM PRODUCED BY A MAIN, FLASH AND BUMP EXPOSURE



APPENDIX C3

PERCENT DOT AREA MEASUREMENT OF FIRST GENERATION HALFTONE FILMS AND THEIR RESPECTIVE SECOND GENERATION HARD DOT CONTACT FILMS PRODUCED BT THREE DIFFERENT EXPOSURE CONDITIONS

| Density of Original | Main Exposure | | | Main and Flash Exposure | | | Main, Flash & Bump Exposure | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soft | Hard | Diff. | Soft | Hard | Diff. | Soft | Hard | Diff. |
| .04 | 99.8 | 97.3 | 2.5 | 97.3 | 89.6 | 7.7 | 98.1 | 76.2 | 21.9 |
| .12 | 99.6 | 95.3 | 4.3 | 96.3 | 87.8 | 8.5 | 96.5 | 61.6 | 34.9 |
| .23 | 98.1 | 90.7 | 7.4 | 92.7 | 79.9 | 12.8 | 87.5 | 38.6 | 48.9 |
| .37 | 95.0 | 84.3 | 10.7 | 87.1 | 65.8 | 21.3 | 72.2 | 27.7 | 44.5 |
| .48 | 90.7 | 73.5 | 17.2 | 80.3 | 54.7 | 25.6 | 57.8 | 22.1 | 35.7 |
| .58 | 85.3 | 61.4 | 23.9 | 73.1 | 46.2 | 26.9 | 48.3 | 19.3 | 29.0 |
| .68 | 78.2 | 51.2 | 27.0 | 65.8 | 39.9 | 25.9 | 41.1 | 16.8 | 24.3 |
| .77 | 65.7 | 43.1 | 22.6 | 59.5 | 34.6 | 24.9 | 36.6 | 14.9 | 21.7 |
| .86 | 57.1 | 36.3 | 20.8 | 54.1 | 30.6 | 23.5 | 33.3 | 13.7 | 19.6 |
| .96 | 49.3 | 28.7 | 20.6 | 47.5 | 26.2 | 21.3 | 30.6 | 12.3 | 18.3 |
| 1.07 | 39.8 | 23.8 | 16.0 | 43.2 | 23.1 | 20.1 | 28.8 | 11.5 | 17.3 |
| 1.22 | 26.5 | 15.8 | 10.7 | 36.8 | 18.4 | 18.4 | 27.0 | 10.1 | 16.9 |
| 1.44 | 14.1 | - | - | 30.4 | 13.4 | 17.0 | 25.5 | 9.2 | 16.3 |
| 1.66 | 4.3 | - | - | 26.2 | 9.4 | 16.8 | 24.7 | 8.8 | 15.9 |
| 1.90 | 1.3 | - | - | 23.8 | 6.0 | 17.8 | 24.3 | 8.3 | 16.0 |

APPENDIX C4

PERCENT DOT AREA MEASUREMENT OF FIRST GENERATION SOFT DOT HALFTONE FILMS AND THEIR RESPECTIVE SECOND GENERATION HARD DOT CONTACT FILMS PRODUCED WITH VARYING AMOUNTS OF BUMP EXPOSURE

| Density of | 10% Bump | Expos. | | 20% Bump | Expos. | | 34% Bump | Expos. | |
|---|---|---|---|---|---|---|---|---|---|
| Original | Soft | Hard | Diff. | Soft | Hard | Diff. | Soft | Hard | Diff. |
| .04 | 98.5 | 83.7 | 14.8 | 98.3 | 77.6 | 20.7 | 98.1 | 76.2 | 21.9 |
| .12 | 97.0 | 73.5 | 23.5 | 96.7 | 65.1 | 31.6 | 96.5 | 61.6 | 34.9 |
| .23 | 89.8 | 50.6 | 39.2 | 88.2 | 42.9 | 45.3 | 87.5 | 38.6 | 48.9 |
| .37 | 76.8 | 37.4 | 39.4 | 73.6 | 31.0 | 42.6 | 72.2 | 27.7 | 44.5 |
| .48 | 62.8 | 29.1 | 33.7 | 59.2 | 24.4 | 34.8 | 57.8 | 22.1 | 35.7 |
| .58 | 53.2 | 24.5 | 28.7 | 49.3 | 21.0 | 28.3 | 48.3 | 19.3 | 29.0 |
| .68 | 45.5 | 21.4 | 24.1 | 42.1 | 18.0 | 24.1 | 41.1 | 16.8 | 24.3 |
| .77 | 40.0 | 19.0 | 21.0 | 37.4 | 16.3 | 21.1 | 36.6 | 14.9 | 21.7 |
| .86 | 36.1 | 16.9 | 19.2 | 34.0 | 14.5 | 19.5 | 33.3 | 13.7 | 19.6 |
| .96 | 32.6 | 14.9 | 17.7 | 30.9 | 13.0 | 17.9 | 30.6 | 12.3 | 18.3 |
| 1.07 | 30.4 | 13.6 | 16.8 | 29.3 | 12.1 | 17.2 | 28.8 | 11.5 | 17.3 |
| 1.22 | 27.5 | 11.6 | 15.9 | 26.8 | 10.5 | 16.3 | 27.0 | 10.1 | 16.9 |
| 1.44 | 25.3 | 9.8 | 15.5 | 25.1 | 9.2 | 15.9 | 25.5 | 9.2 | 16.3 |
| 1.66 | 24.2 | 8.4 | 15.8 | 24.0 | 8.2 | 15.8 | 24.7 | 8.8 | 15.9 |
| 1.90 | 23.4 | 7.5 | 15.9 | 23.6 | 7.5 | 16.1 | 24.3 | 8.3 | 16.0 |
| Main Exposure | | 85 | | | 49 | | | 32 | |
| Flash Exposure | | 215 | | | 224 | | | 229 | |
| Bump Exposure | | 8 | | | 10 | | | 11 | |
| Bump Exposure % | | 10 | | | 20 | | | 34 | |
| Highlight Mid-tone Range | | 4.5 | | | 3.75 | | | 3.29 | |

# APPENDIX C5

PERCENT DOT AREA MEASUREMENTS OF FIRST GENERATION SOFT DOT HALFTONE FILMS AND THEIR RESPECTIVE SECOND GENERATION HARD DOT CONTACT FILMS PRODUCED BY SIX DIFFERENT TEST EXPOSURE CONDITIONS

| | Exposure #1 | | | Exposure #2 | | | Exposure #3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Density of Original | Soft | Hard | Diff. | Soft | Hard | Diff. | Soft | Hard | Diff. |
| .04 | 98.4 | 79.5 | 18.9 | 98.7 | 78.3 | 20.4 | 98.6 | 83.6 | 15.0 |
| .09 | 98.1 | 75.7 | 22.4 | 98.3 | 74.9 | 23.4 | 98.3 | 81.1 | 17.2 |
| .12 | 96.9 | 65.6 | 31.3 | 97.2 | 64.0 | 33.2 | 97.2 | 72.7 | 24.5 |
| .18 | 93.9 | 53.4 | 40.5 | 94.3 | 49.3 | 45.0 | 94.5 | 59.9 | 34.6 |
| .23 | 88.5 | 43.4 | 45.1 | 88.7 | 39.2 | 49.5 | 89.7 | 48.2 | 41.5 |
| .30 | 81.7 | 36.4 | 45.3 | 82.1 | 33.0 | 49.1 | 83.4 | 41.0 | 42.4 |
| .37 | 74.0 | 31.2 | 42.8 | 74.1 | 28.3 | 45.8 | 76.4 | 35.1 | 41.3 |
| .43 | 66.4 | 27.3 | 39.1 | 66.2 | 24.7 | 41.5 | 69.3 | 30.7 | 38.6 |
| .48 | 59.9 | 24.8 | 35,5 | 53.9 | 20.6 | 33.3 | 57.0 | 25.3 | 31.7 |
| .58 | 49.3 | 21.1 | 28.2 | 49.3 | 19.1 | 30.2 | 51.9 | 23.3 | 28.6 |
| .63 | 45.0 | 19.5 | 25.5 | 44.8 | 17.6 | 27.2 | 47.6 | 21.6 | 26.0 |
| .68 | 42.0 | 18.2 | 23.8 | 41.9 | 16.4 | 25.5 | 44.4 | 20.3 | 24.1 |
| .73 | 39.7 | 17.2 | 22.5 | 39.2 | 15.6 | 23.6 | 41.7 | 19.2 | 22.5 |
| .77 | 37.8 | 16.4 | 21.4 | 36.9 | 15.0 | 21.9 | 39.4 | 18.1 | 21.3 |
| .82 | 35.5 | 15.2 | 20.3 | 34.8 | 14.2 | 20.6 | 36.9 | 17.0 | 19.9 |
| .86 | 34.2 | 14.6 | 19.6 | 33.6 | 13.6 | 20.0 | 35.5 | 16.4 | 19.1 |
| .91 | 32.5 | 13.9 | 18.6 | 32.0 | 13.0 | 19.0 | 33.6 | 15.3 | 18.3 |
| .96 | 31.3 | 13.3 | 18.0 | 30.8 | 12.4 | 18.4 | 32.1 | 14.5 | 17.6 |
| 1.01 | 30.4 | 12.7 | 17.7 | 29.9 | 11.6 | 18.3 | 31.0 | 14.0 | 17.0 |
| 1.07 | 29.4 | 12.1 | 17.3 | 29.1 | 11.1 | 18.0 | 30.3 | 13.3 | 17.0 |
| 1.12 | 28.3 | 11.5 | 16.8 | 28.1 | 11.1 | 17.0 | 29.2 | 12.7 | 16.5 |
| 1.22 | 26.9 | 10.7 | 16.2 | 27.0 | 10.2 | 16.8 | 28.0 | 11.7 | 16.3 |
| 1.33 | 26.0 | 9.9 | 16.1 | 26.0 | 9.6 | 16.4 | 26.8 | 10.7 | 16.1 |
| 1.44 | 25.2 | 9.2 | 16.0 | 25.3 | 9.2 | 16.1 | 25.6 | 10.0 | 15.6 |
| 1.55 | 24.7 | 8.8 | 15.9 | 24.9 | 8.7 | 16.7 | 25.1 | 9.5 | 15.6 |
| 1.66 | 24.2 | 8.3 | 15.9 | 24.5 | 7.2 | 17.3 | 24.6 | 8.8 | 15.8 |
| 1.79 | 23.9 | 8.0 | 15.9 | 24.2 | 7.2 | 17.0 | 24.3 | 8.5 | 15.8 |
| 1.90 | 23.6 | 7.8 | 15.8 | 23.9 | 7.7 | 16.2 | 23.9 | 8.2 | 15.7 |
| 2.04 | 23.5 | 7.6 | 15.9 | 23.9 | 7.7 | 16.2 | 23.8 | 8.0 | 15.8 |

| | Exposure #1 | Exposure #2 | Exposure #3 |
|---|---|---|---|
| Main Exposure | 32 | 49 | 69 |
| Flash Exposure | 229 | 224 | 219 |
| Bump Exposure | 11 | 10 | 9 |
| Bump Percent | 34% | 20% | 13% |
| Highlight Mid-tone Range | 3.29 | 3.75 | 4.20 |

# APPENDIX C5

PERCENT DOT AREA MEASUREMENTS OF FIRST GENERATION SOFT DOT HALFTONE FILMS AND THEIR RESPECTIVE SECOND GENERATION HARD DOT CONTACT FILMS PRODUCED BY SIX DIFFERENT TEST EXPOSURE CONDITIONS

| | Exposure #4 | | | Exposure #5 | | | Exposure #6 | | |
|---|---|---|---|---|---|---|---|---|---|
| Density of Original | Soft | Hard | Diff. | Soft | Hard | Diff. | Soft | Hard | Diff. |
| .04 | 98.0 | 83.4 | 14.6 | 96.5 | 84.4 | 12.1 | 96.1 | 88.3 | 37.8 |
| .09 | 97.7 | 80.6 | 17.1 | 96.1 | 83.2 | 12.9 | 95.9 | 87.9 | 8.0 |
| .12 | 96.4 | 75.2 | 21.2 | 94.6 | 78.8 | 15.8 | 95.0 | 86.2 | 8.8 |
| .18 | 94.0 | 66.0 | 28.0 | 92.0 | 72.2 | 19.8 | 93.3 | 82.6 | 10.7 |
| .23 | 89.7 | 55.2 | 34.5 | 88.1 | 63.4 | 24.7 | 90.9 | 77.1 | 13.8 |
| .30 | 84.5 | 47.4 | 36.6 | 83.8 | 56.1 | 27.7 | 88.2 | 71.1 | 17.1 |
| .37 | 77.7 | 41.7 | 36.0 | 78.9 | 49.9 | 29.0 | 84.7 | 64.3 | 20.4 |
| .43 | 71.2 | 36.7 | 34.5 | 73.9 | 44.8 | 29.1 | 80.9 | 57.9 | 23.0 |
| .48 | 64.8 | 32.6 | 32.2 | 69.1 | 40.7 | 28.4 | 76.7 | 52.0 | 24.7 |
| .54 | 59.7 | 29.8 | 29.9 | 64.4 | 37.5 | 26.9 | 73.0 | 48.2 | 24.8 |
| .58 | 55.4 | 26.9 | 28.5 | 59.2 | 34.4 | 24.8 | 68.9 | 44.5 | 24.4 |
| .63 | 51.1 | 25.6 | 25.5 | 55.1 | 31.4 | 23.7 | 64.9 | 41.5 | 23.4 |
| .68 | 47.5 | 23.9 | 23.6 | 51.6 | 29.3 | 22.3 | 61.1 | 38.6 | 22.5 |
| .73 | 44.8 | 22.3 | 22.5 | 48.8 | 27.6 | 21.2 | 58.1 | 36.0 | 22.1 |
| .77 | 42.3 | 21.0 | 21.3 | 46.2 | 25.7 | 20.5 | 54.8 | 33.5 | 21.3 |
| .82 | 39.7 | 19.7 | 20.0 | 43.2 | 23.8 | 19.4 | 51.4 | 30.9 | 20.5 |
| .86 | 37.9 | 18.7 | 19.2 | 41.4 | 22.6 | 18.8 | 48.9 | 29.1 | 19.8 |
| .91 | 35.8 | 17.5 | 18.3 | 38.9 | 20.9 | 18.0 | 45.6 | 26.8 | 18.8 |
| .96 | 34.0 | 16.2 | 17.8 | 36.5 | 19.4 | 17.1 | 42.4 | 24.8 | 17.6 |
| 1.01 | 32.9 | 15.4 | 17.5 | 35.2 | 18.3 | 16.9 | 40.4 | 23.1 | 17.3 |
| 1.07 | 31.6 | 14.6 | 17.0 | 33.6 | 17.1 | 16.5 | 38.1 | 21.5 | 16.6 |
| 1.12 | 29.9 | 13.3 | 16.6 | 31.4 | 15.5 | 15.9 | 35.3 | 19.4 | 15.9 |
| 1.22 | 28.1 | 12.0 | 16.1 | 28.7 | 13.7 | 15.0 | 31.3 | 16.7 | 14.6 |
| 1.33 | 26.3 | 10.2 | 16.1 | 26.4 | 11.3 | 15.1 | 28.2 | 13.6 | 14.6 |
| 1.44 | 25.1 | 8.9 | 16.2 | 24.7 | 9.3 | 15.4 | 25.4 | 10.8 | 14.6 |
| 1.55 | 24.3 | 8.1 | 16.2 | 23.2 | 7.8 | 15.4 | 23.3 | 8.3 | 15.0 |
| 1.66 | 23.8 | 7.1 | 16.7 | 22.3 | 6.4 | 15.9 | 21.5 | 6.0 | 15.5 |
| 1.79 | 23.3 | 6.5 | 16.8 | 21.7 | 5.2 | 16.5 | 20.3 | 3.8 | 16.5 |
| 1.90 | 22.8 | 6.1 | 16.7 | 21.0 | 4.1 | 16.9 | 19.4 | 2.1 | 17.3 |
| 2.04 | 22.5 | 5.6 | 16.9 | 20.4 | 3.7 | 16.7 | 18.6 | 1.5 | 17.1 |

| | Exposure #4 | Exposure #5 | Exposure #6 |
|---|---|---|---|
| Main Exposure | 133 | 235 | 405 |
| Flash Exposure | 205 | 187 | 164 |
| Bump Exposure | 7 | 4 | 0 |
| Bump Percent | 5% | 2% | 0 |
| Highlight Mid-tone Range | 5.2 | 6.2 | 7.23 |

# APPENDIX C-6

## FRINGE COMPENSATION METHOD LIST OF PROCEDURES

<u>Part A</u> Identifying dot fringe variability due to various exposure combinations

1. Expose reflection gray scale to film with the following exposure combinations:

   film#1 Main exposure only placing highlight dot in the first step of the gray scale

   film#2 Main exposure plus maximum allowable flash exposure placing highlight dot in the first step of the gray scale

   film#3 Main exposure plus maximum allowable bump exposure placing highlight dot in the first step of the gray scale

2. Contact films 1,2 and 3 simultaneously to contact film. Include transmission gray scale and expose to yield same critical density step number used on printing plates.

3. Zero transmission densitometer or dot area meter on film base only and record percent dot area of films 1,2 and 3 and their respective contact films (A,B and C).

4. Subtract percent dot area of films 1,2 and 3 from their respective contact films A,B and C and record as percent dot difference.

5. Plot a curve for each film (1,2 and 3) on separate graphs. Label horizontal axis percent hard dot (contact film) and vertical axis percent dot area correction (films 1,2 and 3 minus films A,B and C).

6. Draw perpendicular lines extending up from the horizontal axis at selected highlight, midtone and shadow aim points. Where perpendicular lines intersect curve, draw lines across to vertical axis.

7. Record dot area correction for each aim point for all three film exposure combinations.

Part B Derive necessary correction data

1. Superimpose and observe curves plotted in Part A. Significant variation (more than 3%) should be apparent between film 3 and films 1 and 2 only.

2. Repeat step A-1 by exposing reflection gray scale using a main exposure and two different, equally spaced, percentages of bump exposure of the maximum bump exposure used previously.

3. Repeat steps A-2 through A-6 for the two additional main plus bump exposure films.

4. Record percent dot area correction values for the varying exposure conditions in Table 1.

Table 1

PERCENT DOT AREA CORRECTION FACTORS FOR SELECTED PERCENT DOT AREA AIM POINTS

| Halftone Percent Dot Area Measured Selected Aim Points For Halftone Negatives | PERCENT DOT AREA CORRECTION VALUES FOR VARYING HALFTONE EXPOSURE CONDITIONS: Halftone Exposures Requiring Main and Flash Exposures — Main or Main and Flash Exposures | Halftone Exposures Requiring Bump Exposures — Selected Bump Exposures Expressed as a Percentage of the Main Exposure X% | X% | X% |
|---|---|---|---|---|
| H | X | X | X | X |
| M | X | X | X | X |
| S | X | X | X | X |

5. Add percent dot area correction values from Table 1 to percent dot area aim points selected and enter data in Table 2.

Table 2

PERCENT DOT AREA REFERENCE TABLE - CORRECTED DOT AREA VALUES FOR FIRST GENERATION HALFTONE FILMS

| Percent Dot Area Aim Points | Required Dot Area Meter Readings For Various Halftone Exposure Conditions: Main and Flash Exposures | Bump Exposures X% | X% | X% |
|---|---|---|---|---|
| H | X | X | X | X |
| M | X | X | X | X |
| S | X | X | X | X |

<u>Part C</u> Test correction data

1. Calculate halftone exposure(s).

2. Expose and process halftone film.

3. Zero densitometer or dot area meter on film base only.

4. Measure identified highlight, midtone and shadow areas of the halftone film.

5. Compare readings of instrument to the required percent dot area from Table 2 for the appropriate halftone exposure condition.

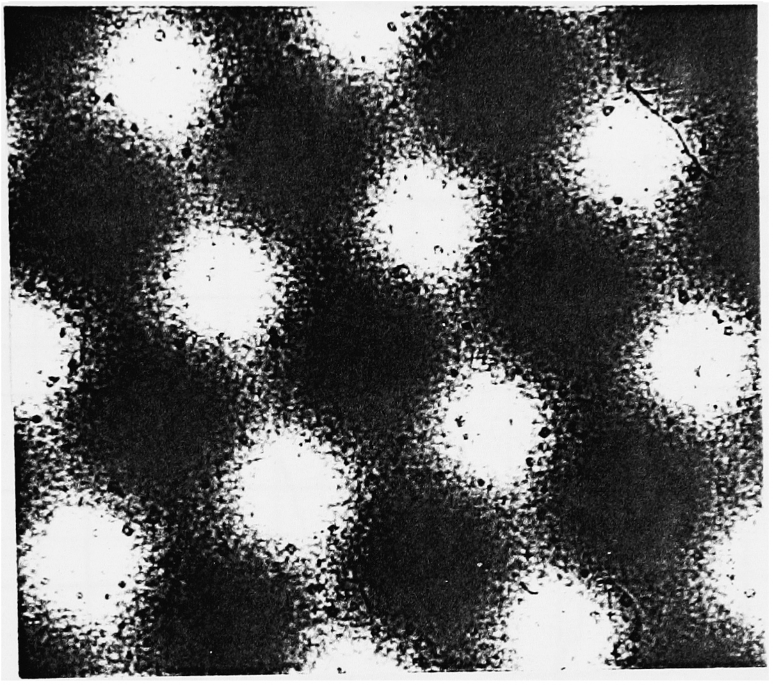
# APPENDIX D

## GENERAL EXPERIMENT DATA

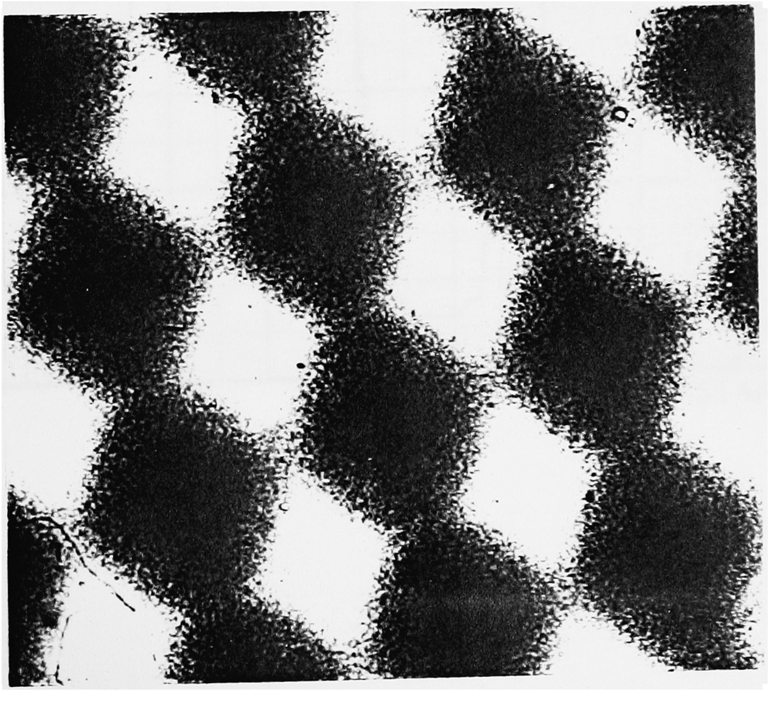
APPENDIX D1

MICROPHOTOGRAPHS OF CONVENTIONAL AND RAPID ACCESS CONTACT SCREENS USED IN THE EXPERIMENT

Repsi conventional contact screen

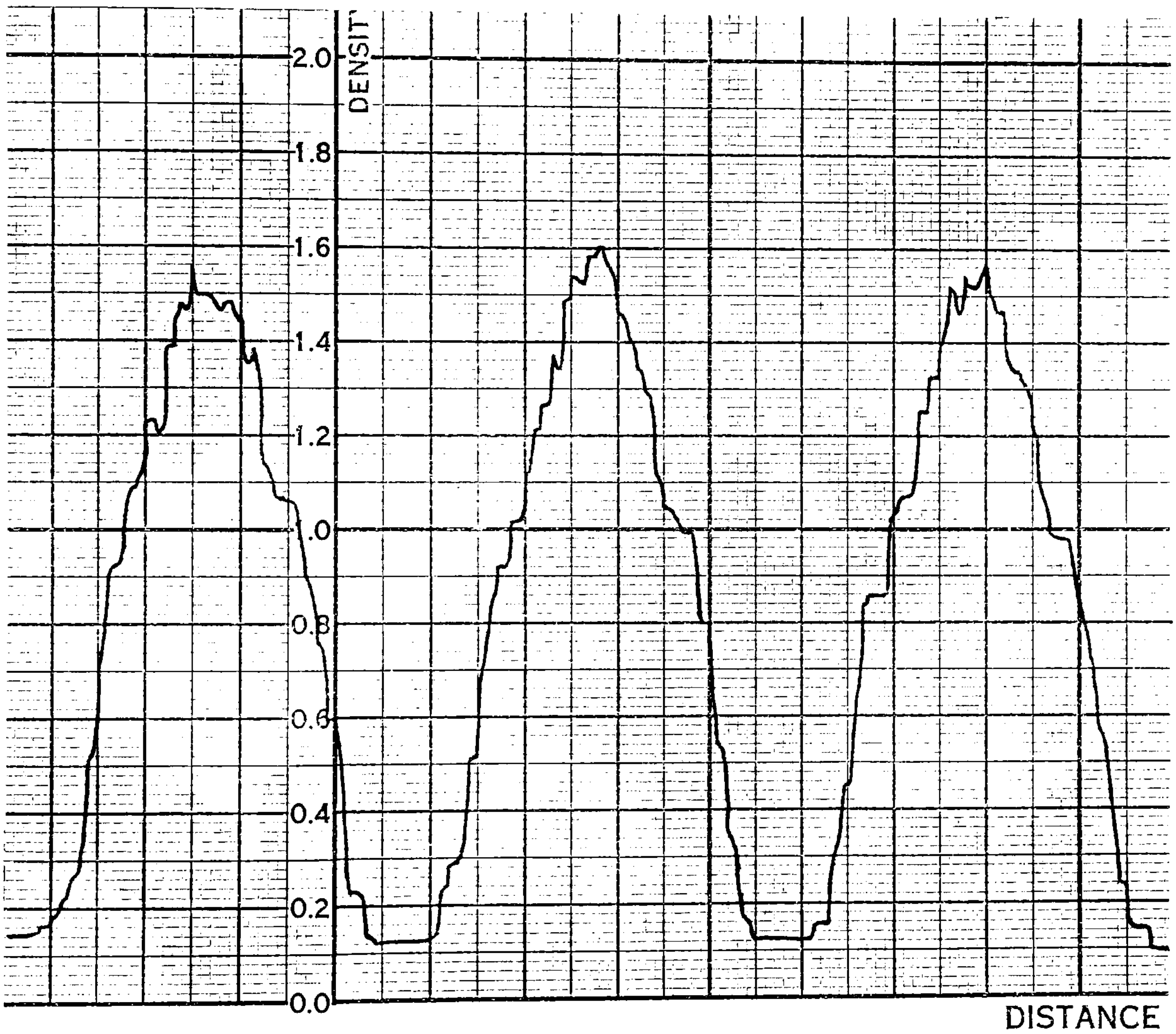


Caprock rapid access contact screen



APPENDIX D2-A

MICRODENSITOMETER TRACE OF CAPROCK GRAY NEGATIVE 133LINE RAPID ACCESS CONTACT SCREEN



APPENDIX D2-B

MICRODENSITOMETER TRACE OF RESPI GRAY NEGATIVE 133 LINE CONVENTIONAL CONTACT SCREEN